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THE BILE FACTOR IN PANCREATITIS

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Among the many explanations of the cause of pancreatitis, the one attributing the condition to a reflux of bile into the pancreatic duct has seemed the most plausible to the greatest number of clinicians and surgeons. The reason for this is probably that the process, seemingly, may take place in man and that it deals with factors concerning which physicians are already acquainted. We have approached the problem of bile as the causative factor in acute and chronic pancreatitis from two aspects, the anatomic and the experimental. The investigation of the problem was suggested several years ago by Dr. E. S. Judd, and during the last six years the condition of pancreatitis has been studied in its general aspects, and several lines of investigation with regard to the most plausible features have been followed. In this article only the possible relation of bile to pancreatitis will be considered. The results of other studies will be published later.

Extensive investigations have been carried out with regard to the cause of pancreatitis. The most complete recent literary review of the subject was published by Sweet.[1] An important percentage of such reviews deal with the bile factor as the cause. Ample evidence[2] is at hand to prove that cholecystitis and chronic and acute pancreatitis coexist in a large percentage of cases. Many statistics have been accumulated to show this,[3] but the cause of such coexistence is still unknown. Two possibilities have been suggested with regard to this relationship and bile as the cause of pancreatitis: (1) A small gallstone or other mechanical obstruction may block the exit of the

1. Sweet, J. E.: The Surgery of the Pancreas, Internat. Clinics **4**:293-357, 1915.

2. Mayo, W. J.: The Surgical Treatment of Pancreatitis, Surg., Gynec. & Obst. **7**:607-613, 1908.

3. Egdahl, A.: A Review of One Hundred and Five Reported Cases of Acute Pancreatitis, with Special Reference to Etiology; with Report of Two Cases, Bull. Johns Hopkins Hosp. **18**:130-136, 1907.

common bile duct so that it forms a continuous channel with the pancreatic duct and allows bile to infiltrate the pancreas, and (2) the sphincter at the duodenal end of the common bile duct may contract and produce the same condition.

The possibility that gallstones lodged in the ampulla of Vater could cause disease of the pancreas by obstruction of the main pancreatic duct was suggested by Lancereaux.[4] Opie [5] asserted that ligation of both pancreatic ducts will cause hemorrhagic pancreatitis, and he reported a case of acute hemorrhagic pancreatitis, with gallstones in the common bile duct near the ampulla causing obstruction; bile had not entered the duct of Wirsung nor was the duct dilated. He collected reports of seven similar cases from the literature and concluded, "The lodgment of a stone near the orifice of the common bile duct, where it may at the same time compress or occlude the pancreatic duct, is not uncommonly the cause of pancreatic lesions and disseminated fat necrosis." In the same year, he [6] reported another case of hemorrhagic pancreatitis in which a calculus, 3 mm. in diameter, was found impacted in the apex of the ampulla of Vater, the diameter of which was 1 mm. The duct of Wirsung opened 7 mm. from the apex of the ampulla so that the pancreatic and common bile ducts were converted into one continuous channel. To prove his contention that bile was the cause of the acute pancreatitis, he injected bile into the main pancreatic duct of dogs, and produced acute pancreatitis in all the animals. Similar experiments have been carried out by Flexner,[7] Cooke and Whipple,[8] Polya,[9] Oser,[10] Binet and Brocq and others,[11] who produced similar conditions in

4. Lancereaux, E.: Traité des maladies du foie et du pancréas, Paris, Doin, 1899.

5. Opie, E. L.: The Relation of Cholelithiasis to Disease of the Pancreas and to Fat Necrosis, Am. J. Med. Sc. **121**:27-43, 1901.

6. Opie, E. L.: The Etiology of Acute Hemorrhagic Pancreatitis, Bull. Johns Hopkins Hosp. **12**:182-188, 1901.

7. Flexner, Simon: Experimental Pancreatitis, Johns Hopkins Hosp. Rep. **9**:743-771, 1900; Experimental Pancreatitis, Univ. Penn. Med. Bull. **14**:193, 1901-1902; The Constituent of the Bile Causing Pancreatitis and the Effect of Colloids upon Its Action, J. Exper. Med. **8**:167-177, 1906.

8. Cooke, J. V., and Whipple, G. H.: Proteose Intoxications and Injury of Body Protein. IV. The Metabolism of Dogs with Sterile Abscess, Pancreatitis, and Pleuritis, J. Exper. Med. **28**:223-241 (Aug.) 1918.

9. Polya, E. A.: Zur Pathogenese der acuten Pankreasblutung und Pankreasnekrose, Berl. klin. Wchnschr. **93**:1562-1565, 1906.

10. Oser, L.: Die Erkankungen des Pankreas, Wien. Hölder, 1898.

11. Binet, L., and Brocq, P.: Reproduction expérimentale de la pancréatite hémorragique avec stéato-nécrose et du pseudokyste pancréatique par l'injection de sels de calcium dans le canal de Wirsung, Compt. rend. Soc. de biol. **72**: 341-342, 1920; La rôle du suc intestinal dans la reproduction expérimentale de la pancréatite hémorrhagique avec stéato-nécrose, ibid. **72**:340-341, 1920; Brocq, P., and Morel, L.: Le rôle de la bile dans le reproduction expérimentale des pan-

the pancreas, not only with bile but with many other substances, such as gastric and intestinal juice, hydrochloric acid and calcium chlorid. Flexner went farther and proved that taurocholate, when injected into the pancreatic duct, was more active than glycocholate, and that colloids, such as mucin, agar and gelatin, modified the irritative action of bile. He suggested that when bile is imprisoned in the gallbladder as the result of inflammatory processes, the composition changes in favor of the mucin constituent, thus reducing the diffusibility of the salts. Therefore, theoretically, at least, such bile forced into the pancreatic duct would be less liable to produce acute pancreatitis. Nordmann [12] realized the danger of the injection technic, and in experiments on dogs closed the ampulla of Vater by purse-string suture. Jaundice without hemorrhagic pancreatitis occurred, even though the pancreatic duct was dilated with bile; but when he introduced virulent organisms into the common bile duct of such dogs, acute hemorrhagic pancreatitis developed.

The possible importance of the sphincter at the duodenal end of the common bile duct, which is a definite anatomic and physiologic structure, in pancreatitis, was suggested by Archibald.[13] He says that he has produced acute hemorrhagic pancreatitis by introducing into the gallbladder of cats, bile or bile salts incubated for various lengths of time with bacteria, and by forcing this to enter the pancreatic duct by spasm of the sphincter, owing to sudden rise of pressure in the gallbladder from 200 to 700 mm. of water, or to application of hydrochloric acid (5 to 15 per cent.) to the mucous membrane of the duodenum. The animals lived from thirty minutes to several days. Necropsy of those that lived a few hours revealed acute hemorrhagic pancreatitis and multiple focal abscesses in the liver; of the others, various degrees of

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creatities hemorragiques avec stéato-nécrose, ibid. **71**:371-372, 1919. Brocq, P.: Note sur la réalisation expérimentale de la pancréatite hémorragique par stase duodénale, Bull. et mém. Soc. de Chir. de Paris **47**:7-8, 1921. Hewlett, A. W.: On the Occurrence of Lipase in the Urine as a Result of Experimental Pancreatic Disease, J. Med. Research **11**:377-397, 1904. Hlava, J.: L'hémorrhagie, l'inflammation et la gangréne du pancreas, Praze, 1898. Petersen, W.; Jobling, J. W., and Eggstein, A. A.: Serum Changes and the Cause of Death in Experimental Pancreatitis: Studies on Ferment Action. XXX, J. Exper. Med. **23**:491-498 (April) 1916. Speese, J.; Sailer, J., and Torrey, R.: Further Experiments in the Toxemia of Experimental Acute Pancreatitis, Tr. Ass. Am. Phys. **26**:446-450, 1911.

12. Nordmann, O.: Experimente und klinische Betrachtungen über die Zusammenhänge zwischen acuter Pankreatitis und Erkrankungen der Gallenblase, Arch. f. klin. Chir. **102**:66-120, 1913.

13. Archibald, E., and Mullally, E. J.: Some Observations on the Diagnosis and Treatment of Subacute and Chronic Pancreatitis, Canad. M. A. J. **3**:87-97, 1913; Archibald, E.: A General Consideration of Pancreatitis, Internat. Clinics **2**:1-20, 1918; The Experimental Production of Pancreatitis in Animals as the Result of the Resistance of the Common Duct Sphincter, Surg., Gynec. & Obst. **28**:529-545 (June) 1919.

fibrosis in the pancreas. These various investigations have proved that acute pancreatitis may be produced by the injection of bile or other fluids into the pancreatic duct, and that, in some instances in which the animal recovers from the acute lesion, chronic pancreatitis results. Clinical and necropsy data seem to show that there are cases in which the cause of pancreatitis might readily be attributed to a reflux of bile into the pancreatic duct. Data concerning such cases are very meager, and most of the reported cases are open to serious objections, while the method of experimentation applied, when compared with the possible mechanism that may take place in the human being, may lead to very erroneous conclusions. The reflux of bile into the pancreatic duct has not been proved to be a common cause of pancreatitis.

In order to determine the possible importance of bile in causing pancreatitis, we investigated the subject from anatomic and experimental aspects. We determined the percentage of cases in which there is a possibility, from the anatomic standpoint, that bile may pass into the pancreatic duct either from plugging of the exit of the common bile duct with a stone or by the action of the sphincter at the duodenal end of the common bile duct. We studied the anatomic disposition of the sphincter in order to determine whether or not it actually could convert the two ducts into a continuous channel. Experimentally, we determined the maximum pressure which can be produced in the common bile duct by the physiologic mechanism. We studied the effect of the injection of bile into the pancreatic duct at these pressures thus obtained and compared it with the results of injecting bile with a syringe, which was the method employed by previous investigators. We studied the result of forcing bile into the pancreas with the extant physiologic mechanism in a species of animals in which the pancreatic duct empties into the common bile duct. From the correlation of these data we have drawn definite conclusions with regard to the bile as a cause of pancreatitis.

Probably no region in the body, in different species or in individuals of the same species, presents more variations than are found in the relation of the component parts of the biliary tract [14] to one another, to the pancreatic duct,[15] and to the pancreas, and the relation of all to the duodenum.[16] The comparative anatomy of the biliary tract shows a great variety of arrangement of the component parts; in like manner

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14. Mann, F. C.; Brimhall, S. D., and Foster, J. P.: The Extrahepatic Biliary Tract in Common Domestic and Laboratory Animals, Anat. Rec. **18**:47-66, 1920.

15. Mann, F. C.; Foster, J. P., and Brimhall, S. D.: The Relation of the Common Bile Duct to the Pancreatic Duct in Common Domestic and Laboratory Animals, J. Lab. & Clin. Med. **5**:203-206 (Jan.) 1920.

16. Letulle, M., and Nattan-Larrier: Région vatérienne du duodénum et ampoule de Vater, Bull. Soc. anat. de Paris **12**:491-506, 1898. Van Balen Blanken, G. C.: Bijdrage tot de kennis der anatomie van pancreas en lymphaatstelsel der primaten, Amsterdam, N. V. Drukkerij "de Nieuwe Tijd," 1912.

a comparison of the relationship between the bile duct and the pancreatic duct reveals great variability. Furthermore, the method by which the bile duct or pancreatic ducts enter the duodenum is exceedingly variable not only in very closely related species, but also in individuals of the same species. Bearing in mind this variability in arrangement, we have not attempted to study in detail the anatomic points in question, but have only considered whether or not it is definitely possible for the relation of the common bile duct and pancreatic duct in any individual case to be such that a properly located obstruction, whether caused by stone or sphincteric action, could cause a reflux of bile into the pancreatic duct.

Opie,[17] in an examination of 100 specimens, found that the two ducts opened separately at the summit of the papilla in eleven instances, and in only thirty did the length of the ampulla reach 5 mm.

Baldwin,[18] in a study of the anatomy of the pancreas, found that in 22 per cent. of ninety specimens the ampulla of Vater was absent and the ducts separated by a distinct septum. In 13 per cent. the distance from the ampulla orifice to the septum was 2 mm., and in one the duct of Wirsung was reduced to a fibrous cord. He gives no detailed measurements of the remaining specimens, except that the average distance from the apex of the ampulla to the septum was 4.8 mm. Schirmer [19] studied a series of forty-eight specimens and found that in 47 per cent. the mucosal septum completely separated the two ducts.

Belou,[20] who has made a special study of the biliary tract, investigated the relation of the duct of Wirsung to the common bile duct in fifty specimens and found that in 54 per cent. the two opened into the duodenum, either separately or at the apex of the ampulla of Vater; in 30 per cent. the duct of Wirsung opened from 1 to 2 mm. from the apex, while in the remaining 26 per cent. measurements were lacking. The foregoing review affords evidence that a considerable difference exists between the results of the various observers, and, further, that a more detailed study of the exact length of the ampulla of Vater is necessary, especially with reference to the percentage frequency of the various lengths.

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17. Opie, E. L.: The Anatomy of the Pancreas, Bull. Johns Hopkins Hosp. **14**:229-232, 1903.

18. Baldwin, W. M.: The Pancreatic Ducts in Man, Together with a Study of the Microscopical Structure of the Minor Duodenal Papilla, Anat. Rec. **5**: 197-228, 1911.

19. Schirmer, A. M.: Beitrag zur Geschichte und Anatomie des Pankreas, Basel, Reinhardt, 1893.

20. Belou, P.: Anatomia de los conductos biliares y de la arteria cistica, Buenos Aires, Imp. "Oceana," 1915.

In order to verify the discrepancies reported concerning the exact relations of the common bile duct to the duct of Wirsung, human specimens from 200 consecutive necropsies were carefully dissected. At first the dissection was carried out in fresh preparation; but this method was soon discarded because of the difficulty encountered in preserving the delicate membranous septum which often separates the duct of Wirsung at the duodenal end from the common bile duct.[21] The duodenum and pancreas were removed in toto and the duodenum was opened anteriorly. The common bile duct was then incised at a point near the cystic duct and opened to the duodenal end. By cutting the pancreas transversely, the main pancreatic duct was exposed and carefully dissected up to a point about 2 cm. from the wall of the duodenum. After the specimen had been fixed in liquor formaldehydi for twenty-four hours, the duct of Wirsung was again followed to the wall of the duodenum. The opening was ascertained by carefully passing a flexible wire, about 2 mm. in diameter, with a rounded polished end, into its

TABLE 1.—DATA ON THE RELATION OF THE DUCT OF WIRSUNG TO THE COMMON BILE DUCT

Group	Location of Opening of Pancreatic Duct	Number of Specimens	Percentage	Distance from the Apex of the Ampulla of Vater to the Dividing Septum in Mm.							
				3	4	5	6	7	8	9	10
1	Separately into duodenum.....	62	31								
2	2 mm. from the apex of ampulla of Vater.....	90	45								
3	3 mm. to 10 mm. from the apex of the ampulla of Vater.....	40	20	28	5	3	0	1	2	0	+1
4	Duct absent or reduced to fibrous cord	8	4								
	Total.....	200									

lumen, and allowing it to follow the course of least resistance until it reached the exit. Careful measurements were taken of the distance of the opening from the duodenal end of the common bile duct. To prove that the wire had not deviated from the lumen of the duct, various procedures were used, such as injecting methylene blue into the duct and subsequently laying it open and examining the surrounding tissues.

The results obtained may be grouped thus: (1) Both ducts empty into the duodenum separately, contiguous to each other, or at separate points (Figs. 1 and 2); (2) both ducts are contiguous and their extreme ends open into the ampulla from 1 to 2 mm. from the apex; (3) the ducts empty into a common ampulla from 1 to 10 mm. from the apex, and (4) the duct of Wirsung is reduced to a fibrous cord or absent.

It is evident that the common bile duct and the pancreatic duct could be converted into a continuous channel by a blockage of the exit of the

21. Oneto, A. A.: Anatomia del duodeno y pancreas, Semana méd. 1920, p. 27.

ampulla only in Group 3 (Table 1), in which the two ducts drain into the duodenum through a common opening; and even in this group the process can only be brought about in cases in which the pancreatic duct empties into the ampulla at a greater distance from the exit than the diameter of the common opening. The average diameter of the ampulla is from 2.5 to 3.5 mm. Thus, a calculus must be 4 mm. in diameter before it can cause obstruction, except in rare instances. A calculus, 2 mm., or less, in diameter, may obstruct, but eventually it will force

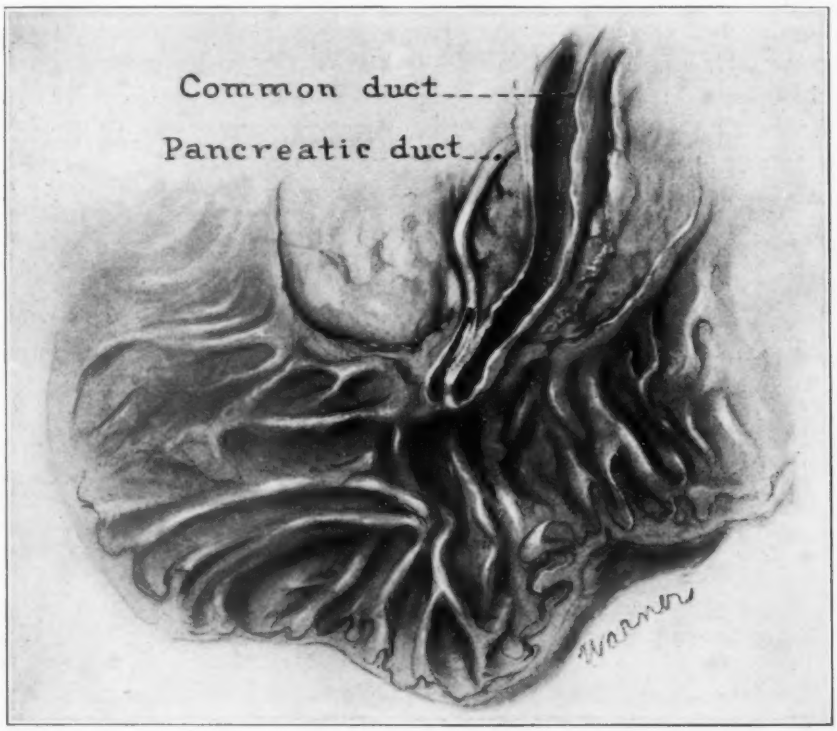

Fig. 1.—Entrances of the common bile duct and pancreatic duct into the duodenum. It is impossible for the ducts to be converted into a continuous channel when this relationship exists.

its way through. It is common experience to find gallstones larger than this in the duodenum. It should also be noted that the dimensions of the ampulla and the ducts entering it are often such that a calculus which would become impacted would obstruct both ducts and not convert them into a continuous channel. Of the 20 per cent. of our specimens in which the two ducts entered together, in twenty-eight instances (14 per cent.), the opening of the duct of Wirsung was 3 mm. from the apex and in five (2.5 per cent.), 4 mm. from the apex.

In these instances reflux of bile into the pancreatic duct because of obstruction would not be possible. This leaves a total of 3.5 per cent. of cases in which it would be anatomically possible for obstruction of the exit of the ampulla to convert the two ducts into a continuous channel and allow bile to pass into the pancreatic duct (Fig. 3).

The sphincter at the duodenal end of the common bile duct has been proved anatomically and physiologically to be a definite structure. Little is known with regard to its physiologic mechanism. We have found it difficult to obtain definite data concerning its function and its physiologic importance.[22] Our observations, based on the histologic examination of hundreds of sections obtained from fifteen species of animals [23] and a physiologic study [24] of ten species of animals, incline us to believe that clinical imagination had greatly preceded demonstrated facts. Our data on this subject will be presented in a future report.

Fig. 2.—Specimen illustrating the anatomic relation shown in Figure 1, which relationship existed in 31 per cent. of the 200 specimens.

The idea that the sphincter of the common bile duct, by contracting, might convert it and the pancreatic duct into a continuous channel is novel and interesting. However, in order to accomplish this, the sphincter would have to be located around the exit of the ampulla and distal to the opening of both ducts, and even then the reflux of bile into the pancreatic duct could occur only if both ducts opened into the ampulla, which in our series occurred in 20 per cent.

22. Mann, F. C.: Unpublished data.

23. Mann, F. C.: A Comparative Study of the Anatomy of the Sphincter at the Duodenal End of the Common Bile Duct with Special Reference to Species of Animals Without a Gallbladder, Anat. Rec. **18**:355-360, 1920.

24. Mann, F. C.: A Study of the Tonicity of the Sphincter at the Duodenal End of the Common Bile Duct, with Special Reference to Animals Without a Gallbladder, J. Lab. & Clin. Med. **5**:107-110 (Nov.) 1919.

While Glisson [25] believed that a sphincter existed at the end of the common bile duct, it was first described by Gage,[26] who studied the sphincter in the cat, and found sphincters around the pancreatic and common bile ducts, and one group of muscle fibers passing around both ducts.

Oddi [27] made an extensive comparative anatomic and physiologic study of the sphincter, employing many species of animals; but aside

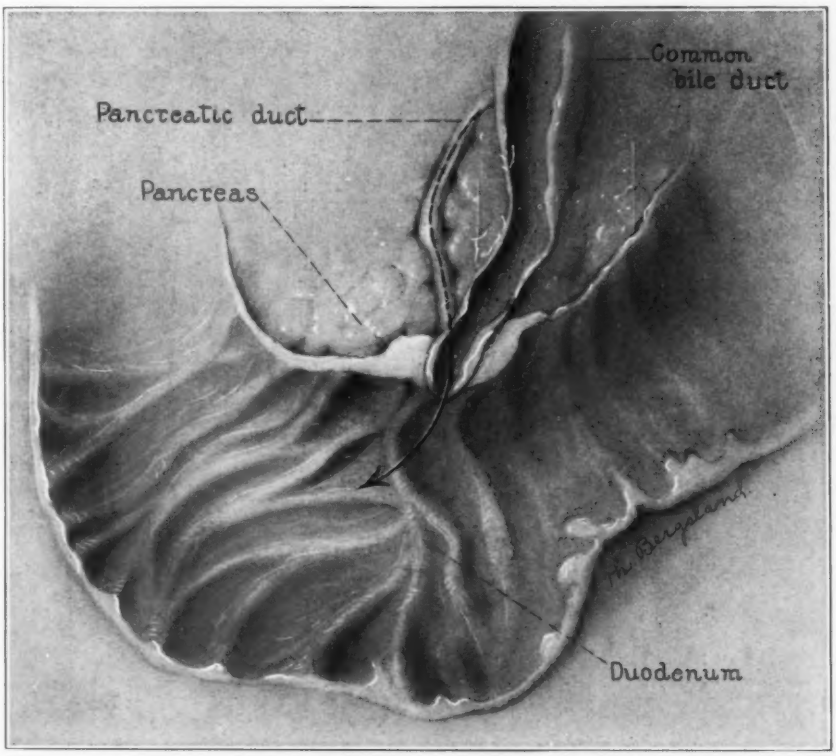

Fig. 3.—Entrance of the common bile duct and pancreatic duct into the duodenum through a common opening; which arrangement occurred in 20 per cent. of the specimens.

from assigning a special sphincter to the duct of Wirsung, he did not study especially the relation of the sphincter of the common bile duct

25. Glisson, quoted by Oddi: Arch. ital. de biol. **8**:317-322, 1887.

26. Gage, S. H.: The Ampulla of Vater and the Pancreatic Ducts in the Domestic Cat (Felis domestica), Am. Quart. Micr. J. **1**:128, 169, 1879.

27. Oddi, R.: D'une disposition à sphincter speciale de l'ouverture de canal choledoque, Arch. ital. de biol. **8**:317-322, 1887; Sulla tonicita dello sfintere del coledoco, Arch. per le sc. med. **12**:333-339, 1888.

to the pancreatic duct. Hendrickson [28] studied the sphincter in man, in the dog, and in the rabbit. His specimens show muscle fibers surrounding both the common bile duct and the duct of Wirsung. All observers note a marked individual variation of the disposition of the muscle fibers constituting the sphincter. Our data verify the observations of variability.

The observations we have made on the histology of the sphincter of the common bile duct, which are particularly applicable to this subject, have to do with the disposition of the muscle fibers of the

Fig. 4.—Photomicrograph of the common bile duct (*a*) and pancreatic duct (*b*) just distal to the point at which they have pierced the muscularis of the duodenum. The bundles of smooth muscle fibers pass around each duct separately; some of them pass around both ducts. These muscle fibers interlace intimately and if they should contract as a whole, both ducts would be closed; ×20.

sphincter in man with regard to the duct of Wirsung. As we have indicated, if Archibald's theory is correct, the sphincter must be placed distal to the entrance of both ducts in the ampulla. A careful

28. Hendrickson, W. F.: A Study of the Musculature of the Entire Extrahepatic Biliary System, Including that of the Duodenal Portion of the Common Bile Duct and of the Sphincter, Bull. Johns Hopkins Hosp. **9**:221-232, 1898.

examination of serial preparations of the sphincter in man demonstrates that in most instances this is not the case. The usual position of the muscle fibers constituting the sphincter is proximal to the termination of the common bile duct. Furthermore, the muscle fibers not only surround the common bile duct, but some of them pass around the pancreatic duct (Figs. 4, 5, 6, 7 and 8).[21] Because of this arrangement, it would seem that contraction of the sphincter would close not only the common bile duct but also the pancreatic duct. There is, however, great variation in the disposition of these muscle fibers. In one instance in man, considerable muscle tissue was found distal to the entrance of the two ducts (Fig. 8). If these muscle fibers could

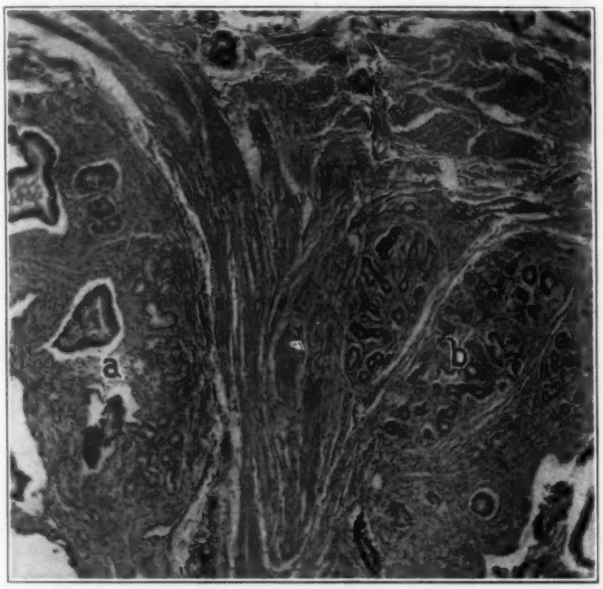

Fig. 5.—Higher magnification of one area of specimen shown in Figure 4, where the two ducts are contiguous, showing the detail of the course of these muscle fibers; × 50.

contract separately, the two ducts would be converted into a continuous channel. In another instance the two ducts joined definitely on the gland side of the sphincter. These observations show that the usual position and arrangement of the sphincter is such that it is not possible for it to convert the ducts into a continuous channel. However, since there is so much variation in the relation of the different structures in connection with this area, there is always the possibility that in a few instances the sphincter might close the exit of the ampulla.

It has been clearly demonstrated that the injection of bile into the pancreatic duct with a syringe will cause acute pancreatitis and death in

a large percentage of cases. However, the injection of an irritating fluid like bile, with a syringe, where a high pressure is developed, produces definite trauma to the gland. It seems to us that before drawing the inference that the condition of the pancreas following intraductal injection of bile under high pressure is identical to the spontaneous cases of pancreatitis observed in man, it would be necessary to determine: (1) the maximal pressure at which the existing physiologic mechanism could inject the bile into the pancreas, and (2) whether

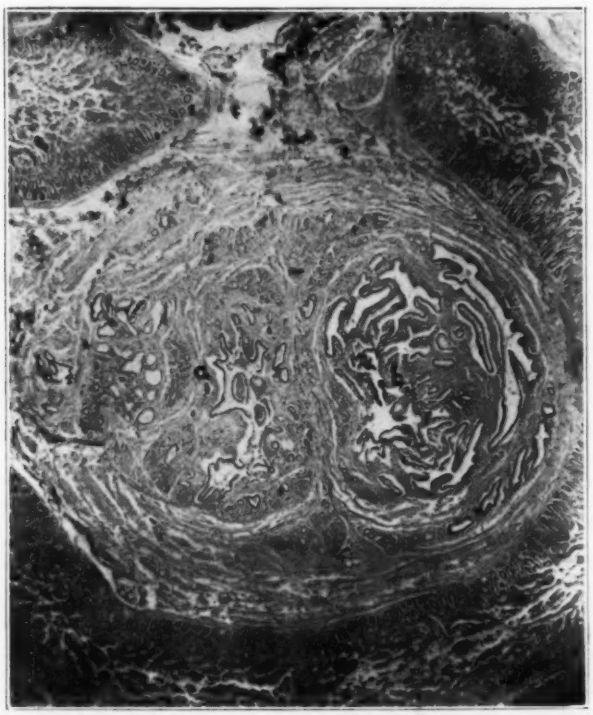

Fig. 6.—Photomicrograph of the common bile duct and pancreatic duct from the series shown in Figure 4, just before the exit of both ducts through a common opening into the duodenum. The ducts are still separated and surrounded by the three groups of muscle fibers; × 20.

pancreatitis could be produced by the injection of sterile bile under this pressure.

The pressure in the common bile duct is due to three factors: (1) the secretory pressure of the liver; (2) the contractile pressure of the gallbladder, and (3) the mechanical pressure exerted by the abdominal muscles and diaphragm on the liver and biliary ducts. We have studied the maximal pressure that is produced in the common bile duct by a combination of all these factors and have made an attempt

to analyze and evaluate the component part of each factor. The experiments were performed on dogs with permanent biliary fistulas. All operations were performed under ether anesthesia and with sterile technic.

The technic for making the fistula has been described.[29] Briefly, it consists of two stages: transplanting the duodenum under the skin so that the point of entrance of the duct at the duodenum is very superficial, and, second, opening the common bile duct on the surface

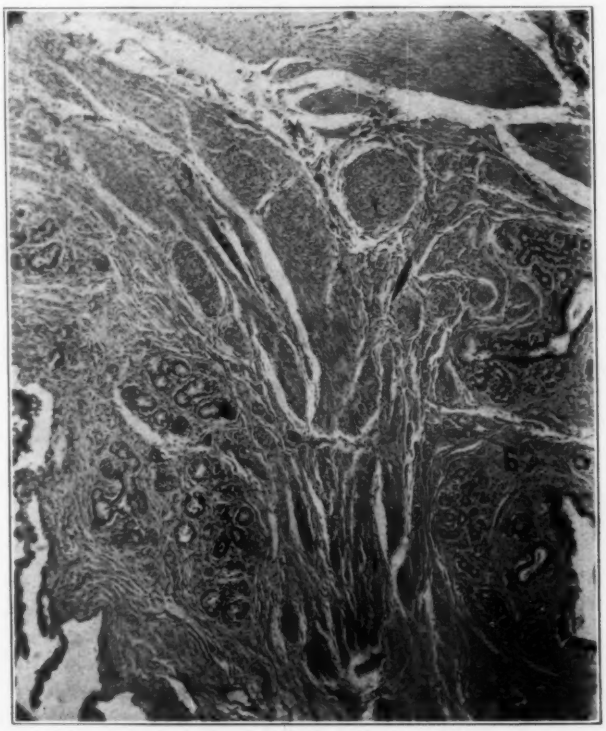

Fig. 7.—Photomicrograph showing the detail of the course of the three groups of muscle fibers making up the group of fibers termed the sphincter. This is taken at a point where the bundles of muscle fibers are the largest. None of the fibers shown belong to the muscularis of the duodenum; × 50.

of the skin. After the wound was healed the following observations were made.

After the preliminary procedure of feeding different kinds of foods, or of fasting, the animal was made comfortable on a table, with the employment of as little restraint as possible. A rubber catheter of

29. Mann, F. C.: A Technic for Making a Biliary Fistula, J. Lab. & Clin. Med. **7**:84-86 (Nov.) 1921.

such a size that it fitted the duct tightly and prevented leakage was inserted into the common bile duct. A glass T-tube was attached to the catheter. To one arm of the T, a rubber tube with a screw clamp was attached, and to the other arm, a straight glass tube. The glass tube was slightly more than 100 cm. in length, had an external bore of approximately 2.5 mm., and was graduated in millimeters (Fig. 9, *a* and *b*). The zero of the scale was at a level corresponding to a plane passed approximately longitudinally through the center of the liver. The pressure was always recorded in millimeters of bile. An

Fig. 8.—Photomicrograph through the ampulla, showing the heavy band of muscle fibers surrounding the channel common to the two ducts. If these particular muscle fibers could contract separately, the two ducts would be converted into a continuous channel. However, these muscle fibers seem to be but a continuation of those that pass around both ducts; × 8.

objection to this method of estimation is that the specific gravity of bile varies. However, other methods that we tried had a greater possibility for error and were not so simple. The animals were always made comfortable and seemed actually to enjoy the periods of observation. Observations were made on some of the animals from three to four times a week, extending over a period of many months.

Secretory pressure of the liver varies in the different species of animals, in various individuals, and under various conditions, such as

food ingestion. We shall report in another study a large number of observations dealing with the effect of various food substances on the secretory pressure of the liver; in this study, only the maximal pressure attainable is of importance.

Our records on the maximal pressure produced in the common bile duct of the dog, due to the secretory activity of the liver, contain several hundred observations extending over many months. They show that a pressure of 350 mm. of bile rarely occurs; and at no time has pressure greater than 375 mm. of bile due to the secretory activity of the liver alone been observed. The average pressure obtained is

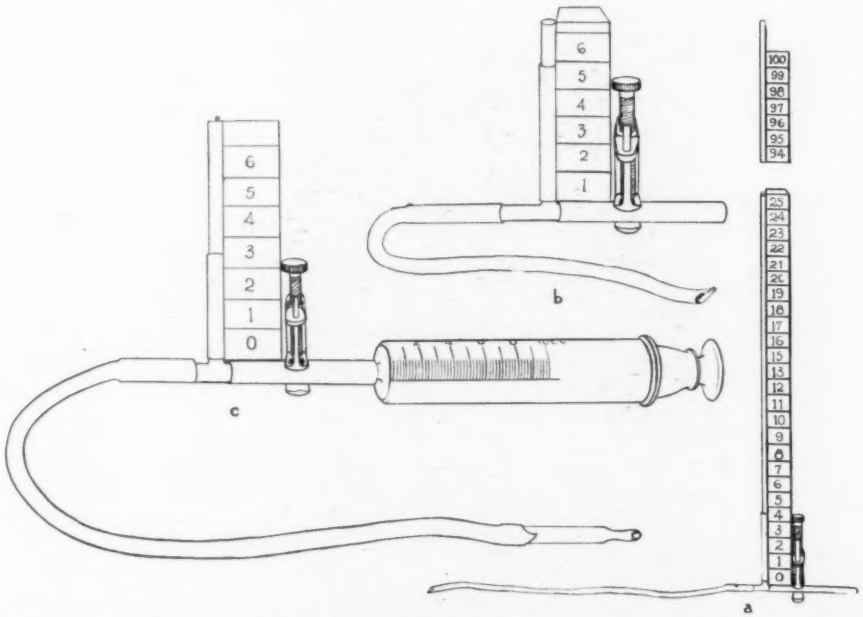

Fig. 9.—Bile manometer: (*a*) the manometer as a whole; (*b*) the detail of the manometer as it was used in estimating the pressure in the common bile duct, and (*c*) the manner in which it was used to inject bile under constant and measured pressure into the pancreatic duct.

less than 350 mm. This coincides with our published data and the findings of other observers.[30]

It is difficult to estimate the part the gallbladder plays in producing pressure in the common bile duct. We attempted to estimate the

30. Herring, P. T., and Simpson, S.: The Pressure of Bile Secretion and the Mechanism of Bile Absorption in Obstruction of the Bile Duct, Proc. Roy. Soc., London **79**:517-532, 1907. Mann, F. C., and Foster, J. P.: The Secretory Pressure of the Liver, with Special Reference to the Presence or Absence of a Gallbladder, Am. J. Physiol. **47**:278-288 (Nov.) 1918. Mitchell, W. T., Jr., and Stifel, R. E.: The Pressure of Bile Secretion During Chronic Obstruction of the Common Bile-Duct, Bull. Johns Hopkins Hosp. **27**:78-79 (March) 1916.

pressure produced by the contraction of the gallbladder, but this was difficult under conditions approximating the normal. The most satisfactory method, so far as maintaining the physiologic integrity of the mechanism is concerned, consisted in observing the fluctuations in pressure in the tube connected to the common bile duct while we were studying the secretory pressure of the liver. If this pressure is observed carefully as it increases, certain rhythmic variations are noted

Fig. 11.—Photomicrograph of a section of pancreas illustrated in Figure 10. The specimen was fixed in liquor formaldehydi fifteen minutes after injection. Marked destruction of the pancreatic tissue has occurred; × 50.

which are not dependent on respiration or other body movements. The rhythmic variations in pressure are not great and the movements are only approximately constant. They were noted in only a relatively small percentage of observations. They seemed to be caused by the contraction of the gallbladder; they were not noted in animals in which this viscus had been removed. These rhythmic variations in pressure were never noted when the pressure had increased in the tube beyond 340 mm. of bile.

It is not possible to draw definite conclusions from these observations; but when they are considered in connection with other

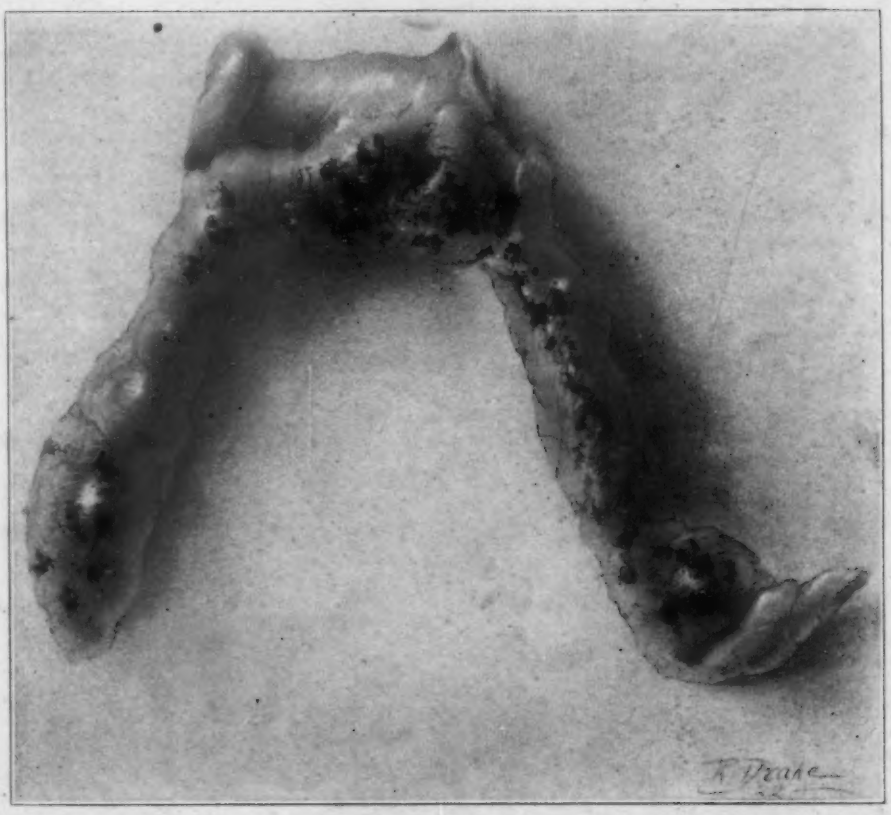

Fig. 10.—Pancreas showing the effect of the injection of 10 c.c. of bile into the major pancreatic duct, with a syringe. The time of injection was less than five minutes. The center of the lobules are discolored, owing to the rupture of the small pancreatic ducts and infiltration of bile into the center of the lobules.

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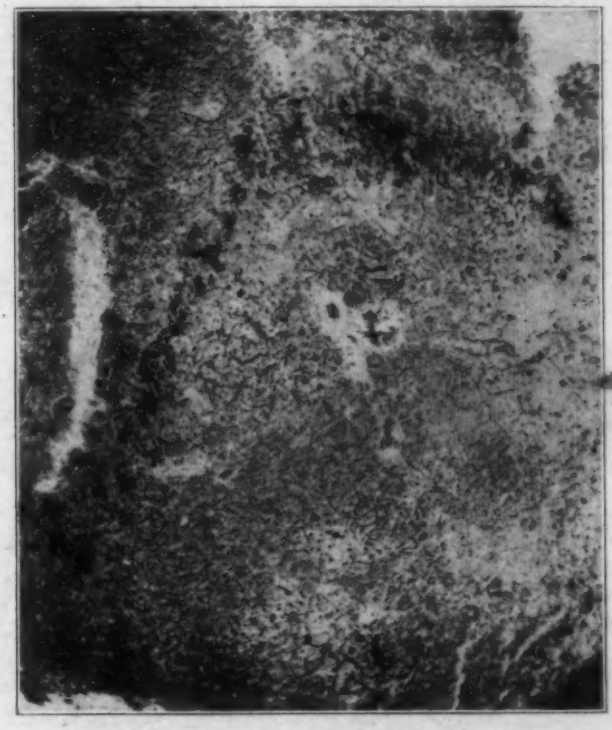

Fig. 11.—Photomicrograph of a section of pancreas illustrated in Figure 10. The specimen was fixed in liquor formaldehydi fifteen minutes after injection. Marked destruction of the pancreatic tissue has occurred; × 50.

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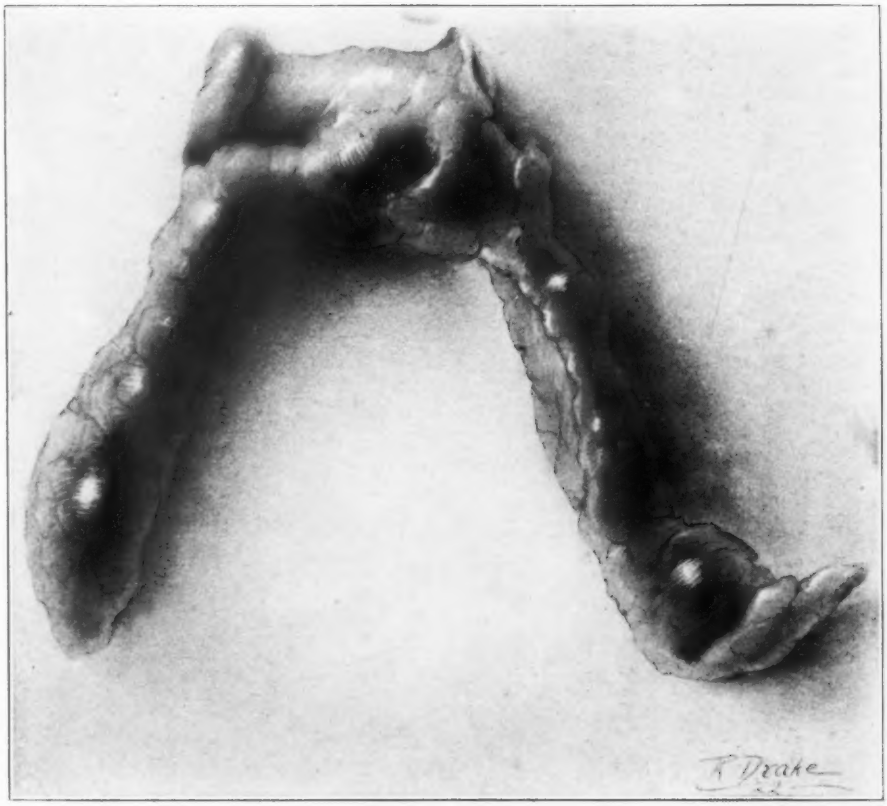


Fig. 10.—Pancreas showing the effect of the injection of 10 c.c. of bile into the major pancreatic duct, with a syringe. The time of injection was less than five minutes. The center of the lobules are discolored, owing to the rupture of the small pancreatic ducts and infiltration of bile into the center of the lobules.

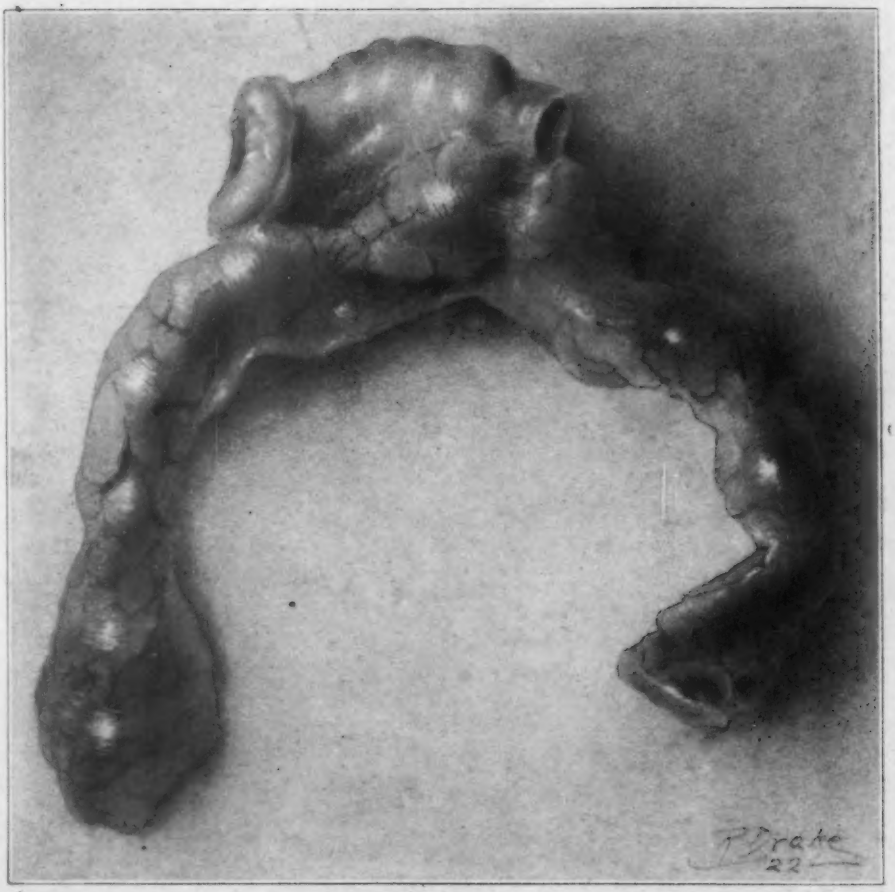
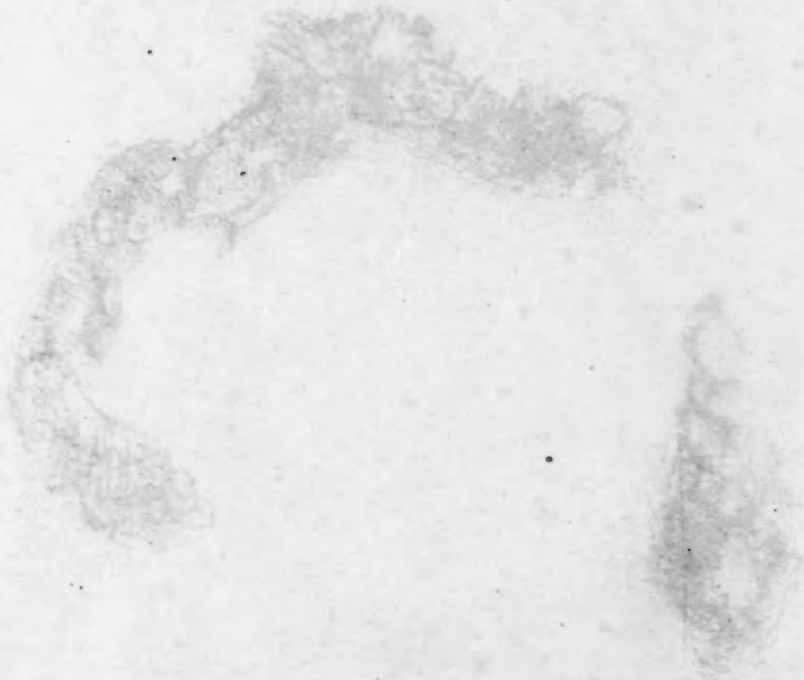


Fig. 13.—Pancreas after the three hour injection of 10 c.c. of bile into the major pancreatic duct with a pressure of 1,000 mm., showing the edema of the organ and the amber colored fluid between the lobules.



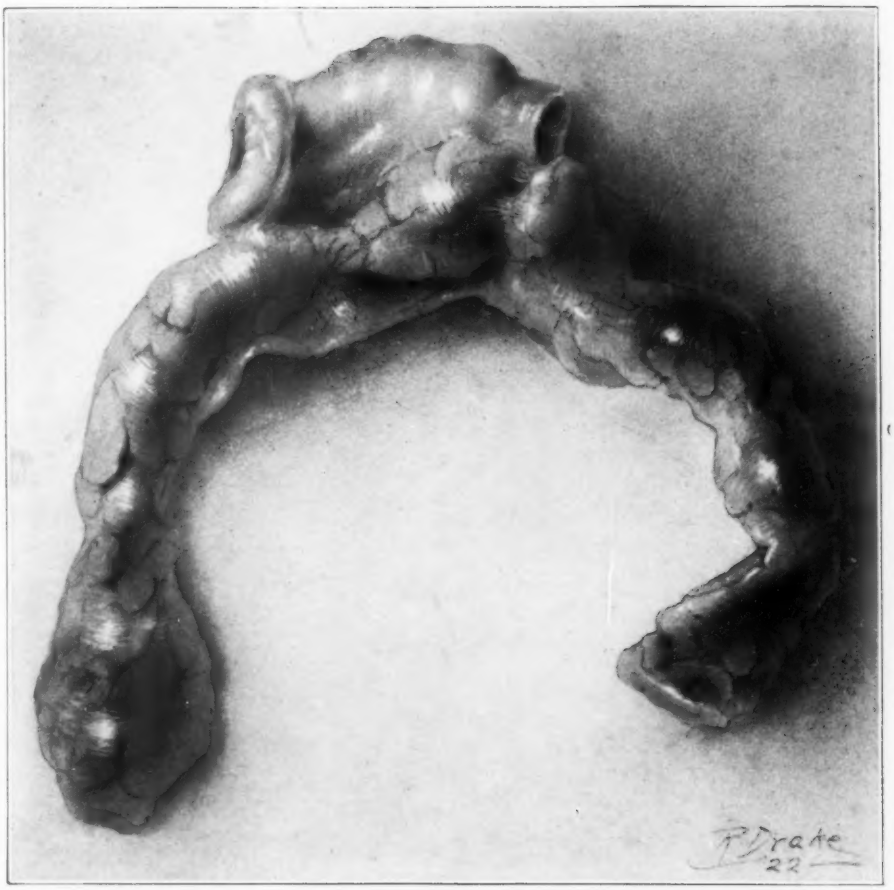


Fig. 13.—Pancreas after the three hour injection of 10 c.c. of bile into the major pancreatic duct with a pressure of 1,000 mm., showing the edema of the organ and the amber colored fluid between the lobules.

observations we have made and with published data,[31] the following statements seem pertinent:

There seems to be no doubt that the gallbladder has a contractile mechanism, exerting pressure on the contents of the biliary tract; but the contractile power of its own intrinsic muscles does not seem to be greater than the pressure that may be produced by the secretory activity of the liver. It is questionable whether the gallbladder empties itself

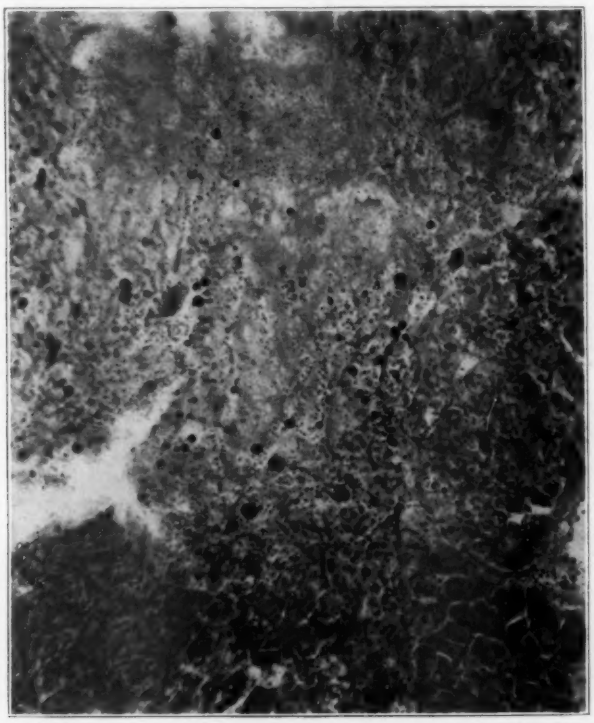


Fig. 12.—A higher magnification of the same section as shown in Figure 11. None of the pancreatic cells or the large coalesced masses of nuclear material appear normal; × 100.

completely by contraction. So far as the maximal pressure produced in the common bile duct is concerned, the gallbladder seems of little consequence.

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31. Bainbridge, F. A., and Dale, H. H.: The Contractile Mechanism of the Gallbladder and Its Extrinsic Nervous Control, J. Physiol. **33**:138-155, 1905-1906. Freese, J. A.: The Force of Contraction of the Gallbladder and the Course of Its Motor and Inhibitory Nerve Fibers, Bull. Johns Hopkins Hosp. **16**: 235-237, 1905. Lieb, C. C., and McWhorter, J. E.: Action of Drugs on the Isolated Gallbladder, J. Pharmacol. & Exper. Therap. **7**:83-98, 1915-1916. Okada, S.: On the Contractile Movement of the Gallbladder, J. Physiol. **1**:42-46, 1915.

Under the conditions of our studies, the mechanical effect of the abdominal muscles and of the diaphragm on the liver and biliary tract produced the most marked changes in the intraductal pressure. Quiet respiratory movements produced a fluctuation of pressure of 1 or 2 cm. of bile. Deep respiratory movements and struggling produced a fluctuation in pressure in the common bile duct greater than that possible by the secretory pressure of the liver or by contraction of the gallbladder. If an animal is made to retch, the intraductal pressure increases enormously, reaching as high as 1,000 mm. of bile. No other conditions produced a pressure as high as that which occurred during vomiting.

Fig. 14.—Photomicrograph of a section of the pancreas shown in Figure 13. The specimen of pancreas was fixed in liquor formaldehydi immediately afterward. The normal contour of the gland substance and the marked edema of the interlobular tissue may be noted; × 50.

Whether the pressure changes in the common bile duct due to the mechanical effect of the abdominal muscles and the diaphragm have any bearing on the problem at hand is not definitely proved. If we assume as correct the usual conception that the abdominal pressure is the same throughout the peritoneal cavity and is exerted equally on all contained viscera, we may ignore the mechanically produced changes. If, however, we grant the possibility of the changes of pressure in the abdomen as affecting various organs differently, because of position, density, and other factors, the act of vomiting is of consid-

erable significance in regard to the injection of bile into the pancreatic duct. Since our present data do not clearly indicate the value to be attached to the mechanically produced changes of pressure in the common bile duct, we have studied the effect of injecting the pancreas at a pressure equal to the maximum obtained, exclusive of the mechanical agencies, and at a pressure equal to the maximum ever obtained.

We have injected sterile bile into the pancreatic duct at various pressures and studied the immediate and remote effects. Only the

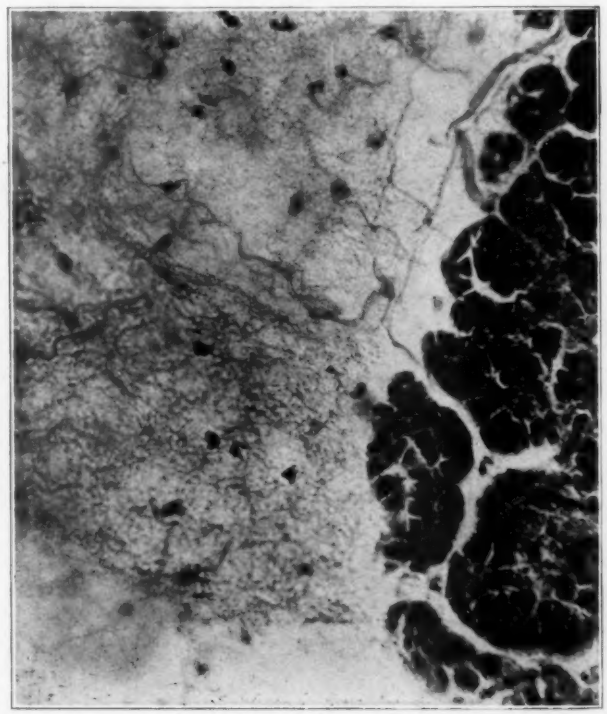

Fig. 15.—A higher magnification of the section shown in Figure 14. The normal appearance of the pancreatic tissue and the edema of the interlobular tissue are illustrated in detail; × 100.

experiments in which bile was injected with a syringe and at a pressure slightly greater than that found in the common bile duct will be discussed here. The experiments were performed on dogs and cats, under ether anesthesia, and with sterile surgical technic in all experiments in which the animal was not etherized at the end of the experiment. The routine procedure was as follows:

The duodenum was exposed and the pancreatic ducts located. In some experiments the minor pancreatic duct was ligated while in others it was left intact. A cannula was placed in the major pancreatic duct

and filled with bile. If the bile was injected with a syringe, this was attached directly to the cannula and the duration of the injection was measured. If the bile was injected at a constant pressure, a bile manometer was used to determine the pressure in the common bile duct. The syringe was attached to the other arm of the T-tube, and the level of bile in the straight tube was kept constant (Fig. 9*c*). Care was taken to avoid the entrance of air into the duct. Usually 10 c.c. of bile was injected.

Fig. 16.—Photomicrograph of a section of the pancreas after the two and one-half hour injection of 10 c.c. of bile into the major pancreatic duct at a pressure of 1,200 mm. The specimen of pancreas was fixed in liquor formaldehydi immediately afterward. The marked edema in the tissue between the lobules and the leukocytic infiltration of this edematous tissue may be noted; × 50.

If from 5 to 10 c.c. of bile is forced with a syringe into the pancreatic duct of a dog, the gland assumes a characteristic mottled brown appearance (Fig. 10). The discoloration is most marked at the center of the lobules; little or no edema of the gland and no change in the relation of the lobules to one another result. When the gland is removed within fifteen minutes after injection, fixed, and studied

histologically, marked and characteristic changes are noted. The force of the injection produces a rupture of the smaller ducts, and bile infiltrates the lobules; hemorrhage from injured blood vessels occurs. The gland cells are swollen; many of the nuclei have disappeared or coalesced to form a large globule of nuclear material. In many areas necrosis occurs (Figs. 11 and 12). If the procedure of injecting the duct has been carried out with sterile technic and the animal has been allowed to recover from the immediate effects of the operation, typical hemorrhagic pancreatitis and death follow in many instances.

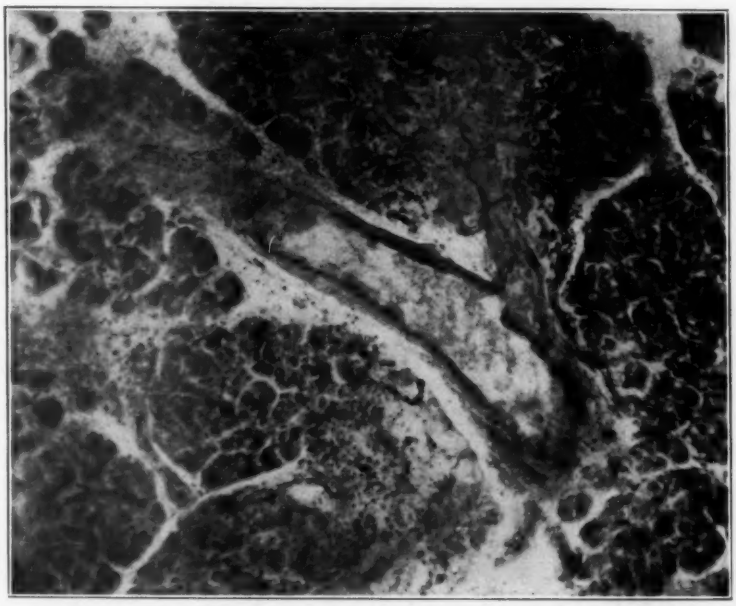

Fig. 17.—Higher magnification of one area showing the rupture of a small bile duct and the infiltration of the surrounding acinar tissue with bile followed by a degeneration of this tissue. This is the lowest pressure with which a rupture of the biliary ducts was produced; × 100.

In experiments in which the bile was injected at pressures approximating those which could possibly occur in the common bile duct, several important observations were made. We were not able to inject bile into the pancreatic duct of a normal dog with a pressure less than 350 mm.; in most experiments bile did not pass into the pancreatic duct at any pressure less than 500 mm. In all experiments bile passed into the pancreatic duct at a pressure less than 800 mm.

The pancreas is injected by means of a syringe in a minute or two. With low pressures the injection takes much longer. Injection of

10 c.c. of bile into the pancreatic duct at 1,000 mm. usually takes from two and one-half to three hours. When lower pressures are used more time is necessary.

The appearance of the pancreas after injection at a pressure of from 800 to 1,000 mm. is quite different from that following injection with a syringe. Grossly, the pancreas is markedly edematous. The fluid seems to pass out of the ducts into the perilobular tissue so that the lobules are spread widely apart. The fluid in the interlobular spaces is amber colored (Fig. 13). The tissues adjacent to the organ also become edematous. Microscopically, the gland tissue appears normal, but edema is observed in the interlobular tissue (Figs. 14 and 15).

In animals in which bile was injected into the pancreatic duct under sterile technic at a pressure of 1,000 mm. or less, acute pancreatitis did not occur except in one instance in which there was fat necrosis of the gland. In other words, we never have produced acute pancreatitis by the injection of bile at any pressure less than 800 mm. Either these low pressures did not force bile into the pancreatic duct, or if bile did pass into the duct it did not produce apparent damage and certainly not acute pancreatitis.

The difference in the results of injection of bile with a syringe and at the lower pressures seems to be due to rupture of the small pancreatic ducts and infiltration of the gland substance by bile, when the syringe is used. Mechanically, this causes great damage to the gland cells and the small blood vessels, frees the pancreatic enzymes, and allows hemorrhage to occur in the gland substance. The bile itself produces changes in the gland cells. The entire process soon appears to be identical with that occurring in spontaneous acute pancreatitis. If the bile passes into the pancreas under lower pressure, less than 1,200 mm. (Figs. 16 and 17), the duct system remains intact, the bile seems to pass through the duct walls and to the interlobular spaces without seriously damaging the gland tissue (Figs. 16 and 17).

In one series of experiments, cannulas were placed in the common bile duct and in the major pancreatic duct pointing toward the respective glands. The minor pancreatic duct was ligated, and the bile manometer was interposed between the two cannulas so that the secretion from one gland could pass into the duct of the other gland and the common pressure in the two ducts could be measured. We were never able to produce sufficient pressure of bile to force it into the pancreatic duct. The intravenous injection of sodium salicylate caused the greatest pressure (300 mm. of bile), owing to the secretory activity of the liver; but this did not cause bile to pass into the pancreatic duct. On the other hand, after pancreatic secretion had been injected intravenously, pancreatic juice exceeded the flow of bile and flowed readily into the common bile duct at a pressure of less than 100 mm.

In a few experiments we estimated the secretory pressure of the pancreas in an anesthetized dog. A cannula in the major pancreatic duct was connected to the manometer previously described. The minor pancreatic duct was ligated. In order to produce the maximal pressure, the pancreas was stimulated by the injection of secretin. The pressures in these experiments varied from 260 to 350 mm., and were similar to those obtained by other investigators.[32] It is thus seen that the

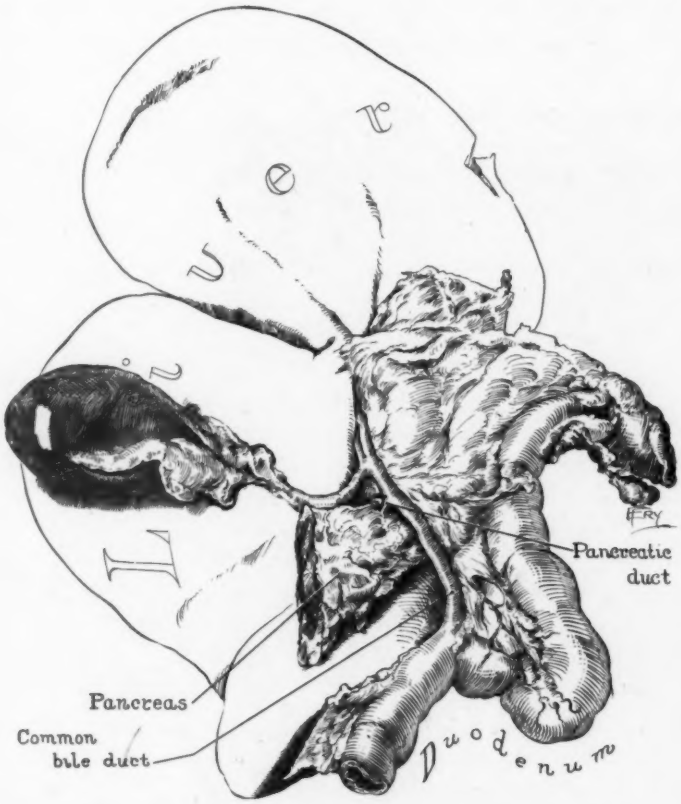

Fig. 18.—Biliary duct of a goat, showing the relation of the common bile duct to the pancreatic duct and duodenum. In our experiments on the goat, the common bile duct was doubly ligated and sectioned as close as possible to its entrance into the duodenal wall.

maximal secretory pressures of the liver and pancreas are about equal. Our results show that the gallbladder does not increase the pressure in the biliary tract more than that due to the secretory activity of the

32. Herring, P. T., and Simpson, S.: The Pressure of Pancreatic Secretion, and the Mode of Absorption of Pancreatic Juice After Obstruction of the Main Ducts of the Pancreas, Quart. J. Exper. Physiol. **2**:99-108, 1909.

liver. If the mechanical changes in intra-abdominal pressure act the same on both glands, the secretory pressures of the two glands are the only factors necessary to consider.

From our experiments the conclusion that hepatitis or cirrhosis of the liver is due to a passage of pancreatic juice into the bile duct would seem almost as justifiable as that pancreatitis is due to a reflux of bile.[33] However, there are authentic cases on record, and we have observed one, in which bile was actually in the pancreatic duct. In consideration of our data this is difficult to explain; but probably it occurs by the conversion of the two ducts into one channel, owing to

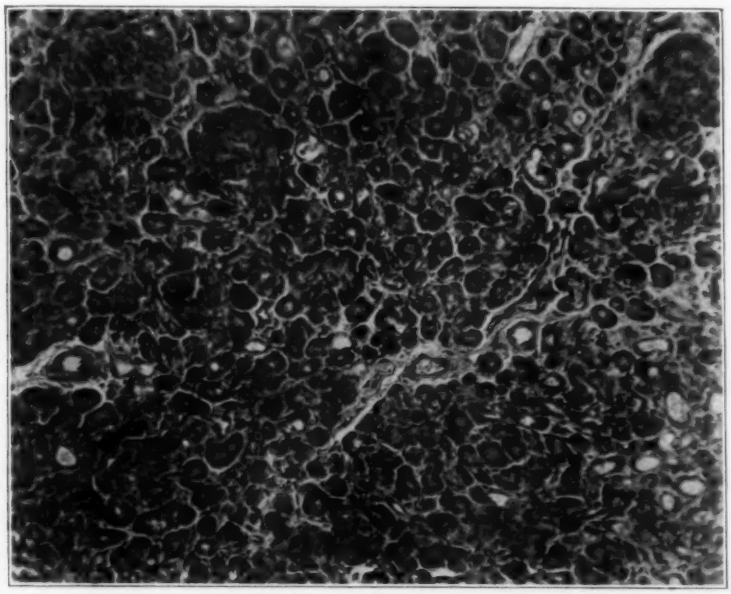

Fig. 19.—Photomicrograph of a section of the pancreas of a goat, taken twenty-four days after ligation of the common bile duct. Grossly the pancreas was bile-stained throughout and green colored fluid escaped from the organ on the slightest abrasion of its surface. On the whole the gland tissue appears normal, with no changes other than those due to obstruction of secretion.

a properly situated mechanical obstruction, or, possibly, to the action of the sphincter. Bile may pass slowly into the pancreatic duct for one, or all, of the following reasons: The secretion of bile is continuous with changes in rate, while the secretion of the pancreatic juice is intermittent. There are times when the pressure in the pancreatic duct

33. Nothnagel: Encyclopedia of Practical Medicine. Diseases of the Liver, Pancreas, and Suprarenal Glands, Philadelphia, W. B. Saunders Company, 1903, p. 642.

might be considerably less than in the bile duct. The liver has firmer tissue and a stronger capsule than the pancreas. With regard to the volume of fluid secreted, the drainage of the intraductal fluid to the outside of the gland is freer in the pancreas than in the liver. While all of these factors would assist in allowing bile to pass into the pancreas, it should be noted that such a mechanism could not possibly rupture the pancreatic duct or infiltrate the gland tissue with bile outside the normal channels. If such a condition brings about pancreatitis by the injection of sterile bile, it must do so by (1) activation of the proteolytic enzyme; (2) bile acting directly on the pancreatic cells, and (3) the

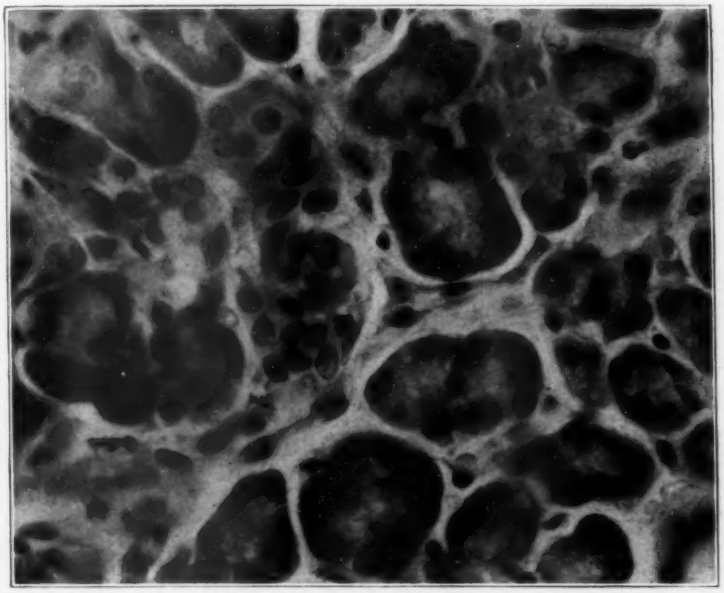

Fig. 20.—A higher magnification of the section shown in Figure 19. Except for the atrophy, the pancreatic tissue appears normal; × 500.

washing of pancreatic enzymes out of their normal channels. It should be emphasized that we have not considered infection in this article.

In an investigation of the relationship of the pancreatic duct to the common bile duct, it was noted that each species studied could be included in one of three groups.[15] In one group the pancreatic duct emptied directly into the common bile duct. The anatomic arrangement of the ducts in this group seemed to offer an ideal condition for determining the existence of a physiologic mechanism which could infiltrate the pancreas with sufficient bile to produce acute pancreatitis. The goat, a readily obtainable animal with a well-developed gallbladder, and one that withstands operation well, was selected from the species that have this relationship of the ducts (Fig. 18).

The operative procedures were simple. Under ether anesthesia and with sterile technic, the bile duct was exposed, doubly ligated and sectioned at its point of entrance into the duodenum. Care was taken not to injure the pancreas; but as the duct passes through the edge of the gland, trauma to the organ could not be wholly avoided. The operative wound was repaired and the animal kept under observation. The procedure was carried out in five goats. The length of life after operation varied from one to thirty days. Three of the animals died directly or indirectly from the results of the operation, one choked to death; one died from intestinal obstruction following ulceration and perforation of the gallbladder with adhesions to a loop of small intestine, and one died from a rupture of a small pancreatic duct, which

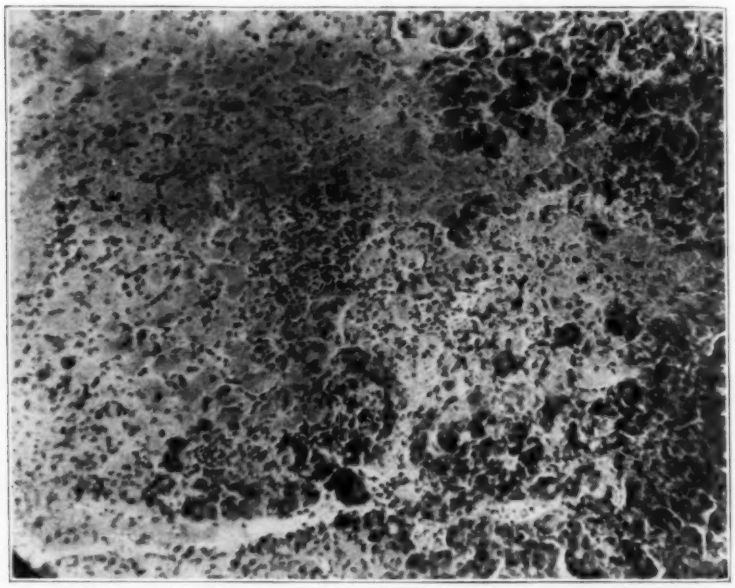

Fig. 21.—Photomicrograph of a section of a goat's pancreas, twenty-four hours after the injection of goat bile into the pancreatic duct with a syringe. The organ presented the characteristic appearance of acute pancreatitis that follows the injection of bile with a syringe.

permitted bile and pancreatic juice to flow into the lesser peritoneal cavity. Two lived until the effect of the occlusion of the ducts to the two glands produced such marked symptoms that they were etherized.

In the animal which died twenty-four hours after operation, the pancreas appeared normal. In one animal which died a few days after operation, no bile was noted in the pancreatic duct, while in three animals, including the two that lived the longest, the pancreatic ducts were dilated and filled with bile-stained fluid. In the

four animals that lived longer than twenty-four hours, well-marked changes, consisting of atrophy of the gland, beginning proliferation of connective tissue and, in one instance, definite intraductal infection, were noted in the pancreas. In none, however, was there, either grossly or microscopically, an area with the appearance of acute hemorrhagic pancreatitis (Figs. 19 and 20). In four of the animals, small areas of fat necrosis were found, in one undoubtedly associated with the trauma of operation. In the three others, the fat necrosis occurred at a point where the pancreas and the affected fatty areas touched, and was probably associated with the obstruction of the pancreatic duct and subsequent leakage of pancreatic juice, because the pancreas is quite friable in the goat.

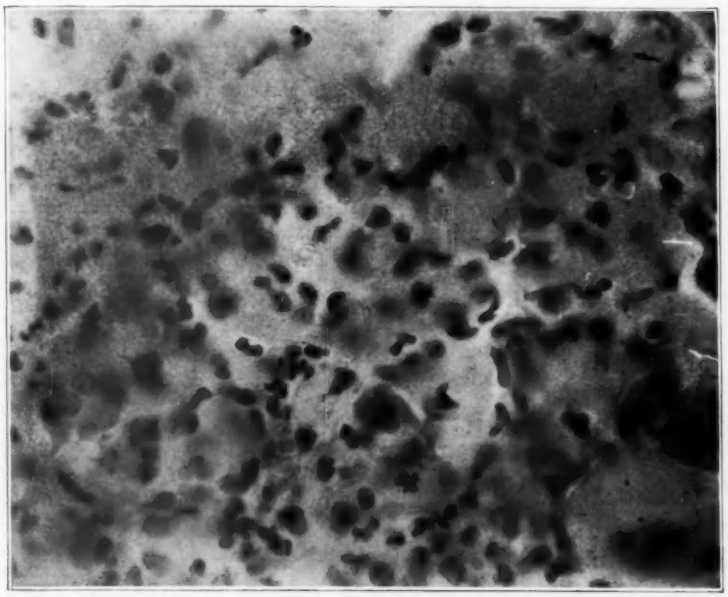

Fig. 22.—A higher magnification of the section shown in Figure 21. The normal arrangement of the pancreatic tissue has been destroyed. Few of the pancreatic cells remain and there is marked infiltration with leukocytes; × 500.

The results of these experiments emphasize that (1) even with the pancreatic duct opening directly into the common bile duct and the latter completely obstructed, bile was not forced into the pancreas except after a considerable length of time, and (2) when bile did pass into the pancreatic duct and infiltrate the pancreas completely under the maximal pressure which the physiologic mechanism of the animal could produce, acute hemorrhagic pancreatitis did not follow.

It seemed essential to investigate two other points: whether acute pancreatitis would take place in goats on injection of bile into the

pancreatic duct, and whether goat bile would produce pancreatitis in other species of animals, the dog and cat. Goat bile was injected into the pancreatic duct of three goats. It was rather difficult to infiltrate the pancreas. The technic consisted of ligating the common bile duct on the gland side of the entrance of the pancreatic duct and placing a cannula in the common bile duct below the entrance of the pancreatic duct. The animal's own bile was withdrawn from the gallbladder and injected with a syringe into the pancreatic duct. In the three cases in which this was done, acute hemorrhagic pancreatitis and death occurred (Figs. 21 and 22). Bile removed from the gallbladder of a goat and injected into the pancreatic duct of two dogs and one cat, 5 c.c. into the cat and one dog, and 10 c.c. into the other dog, caused the usual typical picture of hemorrhagic pancreatitis and death.

When the common bile duct is obstructed below the entrance of the pancreatic duct, it takes a long time before bile can be forced into the pancreatic duct. Eventually, however, the most minute branches of the duct are filled, but all the changes noted in the pancreas may be

TABLE 2.—Comparative Figures Grouped According to Classification

	Percentage in Groups				
Author	1	2	3	4	Specimens
Belou	54	30	?	?	50
Shirmer	47	?	?	?	48
Baldwin	22	13	?	1	90
Opie	11	?	?	?	160
Mann and Giordano	31	45	20	4	200

referable to obstruction of the duct and not necessarily to the presence of bile. While the pancreas showed marked changes in each instance in which the duct had been ligated longer than twenty-four hours, none, other than a few small areas of fat necrosis, was in any way similar to those in acute pancreatitis. In comparing the pancreas of the goats in which bile was infiltrated into the duct by the normal physiologic mechanism with those in which it was injected with a syringe, an extraordinary difference is noted. In the latter the entire abdomen was studded with fat necrosis; the pancreas had either almost entirely disappeared or showed well marked areas characteristic of hemorrhagic pancreatitis.

During our study eleven cases of acute pancreatitis have come under our observation. We made a careful examination of the relationship of the common bile duct and the pancreatic duct and their exit into the duodenum. In none of these cases was it anatomically possible for bile to be injected into the pancreatic duct. In each instance the ducts entered the duodenum separately or the ampulla was so short that an obstruction could not have converted the two ducts into a con-

tinuous channel. Furthermore, our examination proved that in none of these cases could the sphincter have been a factor. However, we have studied one case of chronic pancreatitis in which bile was observed macroscopically throughout the duct system of the pancreas and which could have been produced as the result of sphincteric action.

SUMMARY

We have investigated the bile factor in pancreatitis from two chief aspects, the anatomic and the experimental.

Anatomically, two mechanisms have been suggested whereby bile can be passed into the pancreatic duct. One is based on the possibility that an obstruction could occur at the exit of the common bile duct in such a manner as to convert the two ducts into a continuous channel. We studied the relationship of the common bile duct to the pancreatic duct and their mode of entrance into the duodenum in man in order to determine the percentage of instances in which there would be an anatomic basis for the foregoing hypothesis. Our data conclusively prove that the number of instances in which the anatomic arrangement in the relationship of the two ducts would permit bile to pass into the pancreatic duct is very small. The other possibility that the sphincter at the duodenal end of the common bile duct could contract and convert the two ducts into a continuous channel has beeen investigated. Our data show that in most instances in man the sphincter is located at a point where contraction will close both ducts and will not convert them into a continuous channel. In a very small percentage of instances a small bundle of muscle fibers is found in a position where possibly it could convert the two ducts into a continuous channel. While there is an anatomic basis for the possibility of converting the two ducts into a continuous channel, either by mechanical obstruction or possibly by the action of a sphincter muscle, the percentage of instances in which this could occur is very small.

Experimentally, we followed three lines of investigation: (1) We estimated the possible pressure that the existing physiologic mechanism could exert in order to inject bile into the pancreatic duct, which pressure we have found to be relatively low. (2) We injected sterile bile into the pancreatic duct at the maximal pressure that could occur in the common bile duct. This did not produce typical hemorrhagic pancreatitis, although definite damage of the pancreas sometimes occurred. (3) We ligated the common bile duct in goats (a species in which the main pancreatic duct opens into the common bile duct). This did not produce acute pancreatitis.

Our investigation has proved that an anatomic and physiologic basis for the theory that reflux of bile may occur in the pancreatic duct does exist. The evidence indicates that such a reflux of bile may rarely

be the cause of chronic pancreatitis. The number of instances in which the necessary anatomic conditions are present for such an occurrence is very small. The possibility of bringing into play a physiologic mechanism which can infiltrate the pancreas with sterile bile to an extent actually to produce acute pancreatitis is questionable. Granted that the necessary anatomic, physiologic, and pathologic factors are present and that the reflux of sterile bile under such conditions does produce pancreatitis, such cause for the condition must be very rare; few cases are on record. A reflux of bile could not have been the cause in any of our cases of acute pancreatitis. It should be noted that any mechanism which will afford the possibility of bile's passing into the pancreatic duct will also obstruct the flow of pancreatic juice. Furthermore, bile has been found in the pancreatic duct without acute pancreatitis. Pathologists should, in all cases of pancreatitis, examine the relationship of the two ducts to the duodenum and to each other in order to determine whether it is anatomically possible for bile to pass into the pancreatic duct. Our data conclusively prove that we must look elsewhere for the explanation of the cause of most cases of pancreatitis.

END-RESULTS OF FIVE HUNDRED CASES OF CHRONIC APPENDICITIS

A STATISTICAL STUDY

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The material presented in this paper is derived from a statistical and follow-up study of 500 cases of chronic appendicitis in which operation was performed by the surgical staff of the University Hospital. The cases presented are those of patients operated on during the years from 1913 to 1920. Only data which we felt were wholly reliable and complete were used, but there was no selection of cases. In order to see whether we could find any relationship between chronic appendicitis and upper abdominal disease, we have also presented some statistics from seventy-six cases of gallbladder disease and eighteen cases of gastric and duodenal ulcer. We have endeavored to approach the data with minds unprejudiced by any previous opinions.

SEX AND AGE INCIDENCE

The series includes 260 males and 240 females. The difference between the number of males and females can be accounted for by the fact that there are nearly twice as many beds available for males as females in the surgical wards of this hospital. It would, therefore, seem that though the number is higher in the male, the actual percentage may be higher in the female. La Roque in 400 cases found a predominance of females. Maylord, in a large series of all types of appendicitis, found little difference in the sex incidence.

Table 1 shows the sex and age incidence of chronic appendicitis, and Chart I graphically represents this.

In both males and females, there is a very small number of cases in the first decade, there being but two among males and two among females. This agrees with the findings of other investigators, in that the majority of cases in the first decade are of the acute type. The rarity of the diagnosis in the first ten years of life may be due to the fact that digestive disturbances in children are so frequent and so often caused by indiscretions in diet that unless there are acute symptoms our attention is rarely directed to the appendix. It has been suggested that some of the cases of persistent vomiting may be due to a reflex from a chronically diseased appendix.

After the first decade, we find a dissimilarity in the age and sex incidence, for in the years from 10 to 20 there are forty-one males (15.7 per cent.) and eighty-nine females (37.08 per cent.) in our series.

This is not in accord with Maylord's series, which shows a greater number of males than females in the second decade and the reverse in the third decade. It should be remembered that Maylord included all types of appendicitis. The fact that the highest point in the female curve is reached during that period at which menstrual function is established may be significant. Several factors may play a part in this. Clinically, it is recognized that the menstrual hyperemia aggravates the condition of chronic appendicitis, for the pain often is felt more at this time or only at this time. Formerly, it was thought that women, because of the periodic pelvic hyperemia, were relatively immune to appendicitis; but the exacerbations of chronic appendicitis and the frequent onset of attacks of acute appendicitis at the time of menstruation lead one to believe that this very hyperemia may aggravate the condition in an already diseased organ.

TABLE 1.—SEX AND AGE INCIDENCE OF CHRONIC APPENDICITIS

Years	Male	Female
5	0	0
5-10	2	2
10-15	12	19
15-20	29	70
20-25	86	65
25-30	47	31
30-35	31	26
35-40	21	9
40-45	14	4
45-50	5	3
50-55	5	1
55-60	1	..
60-65	..	..
65-70	..	2
70-75	1	..
Not given	6	8
Total	260	240

The greatest number of cases in the male in our series occurs during the first half of the third decade, when the number in the female is decreasing. There were eighty-six males (33.08 per cent.) and sixty-five females (22.9 per cent.) during this period. From the fortieth year, we find a steady decline in the number of cases in both sexes, that of the female being more abrupt than that of the male.

Statistics concerning the symptomatology of chronic appendicitis present many difficulties. This is readily appreciated when one considers the difficulties encountered in the diagnosis because of the variability of the manifestations and the many conditions which may simulate it.

The outstanding and almost constant symptom mentioned by the patients was pain. In the majority, the pain was in the right iliac fossa

and was periodic. Others described the pain in a variety of terms which are enumerated in Table 2. In the sixty-five patients complaining of upper abdominal pain, with or without pain in the right iliac fossa, an exploratory incision revealed no upper abdominal lesion. The next most frequent symptom was tenderness in the right iliac fossa, which was present in 367 cases. While tenderness was not a symptom in every case, abdominal pain of one sort or another was present. In a condition in which the diagnosis is frequently difficult, the symptom of pain in the right iliac fossa is extremely suggestive of a diseased appendix.

TABLE 2.—FREQUENCY OF SYMPTOMS

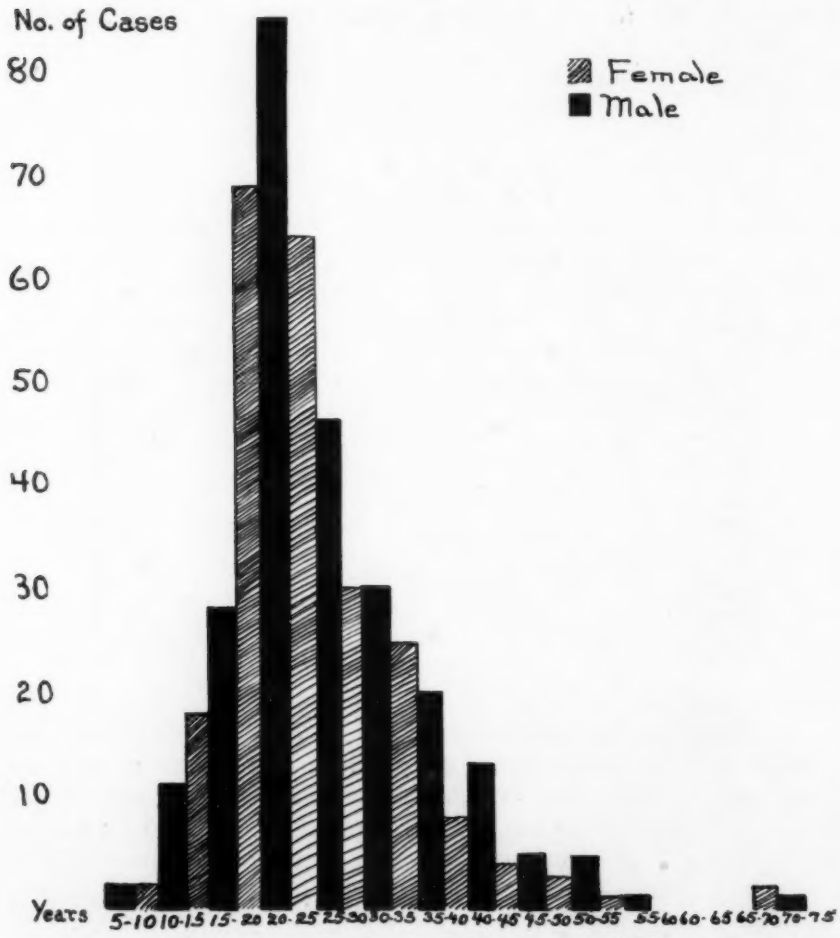
	Cases
Pain:	
Periodic in right iliac fossa	400
Constant in right iliac fossa	81
Dull in right iliac fossa	47
Cramplike in right iliac fossa	42
Burning in right iliac fossa	11
Pain in epigastrium	54
Pain in right upper quadrant	11
Pain after meals	35
Pain relieved by vomiting	7
Tenderness	369
Constipation	213
Nausea	140
Vomiting	135
Belching	96
"Indigestion"	91
Poor appetite	71
Distention	55
Sour regurgitation	53
Diarrhea	18
Jaundice	9
Vomiting blood	5
Borborygmus	4
Hiccups	2

Constipation was complained of in 213 cases. Although this may be etiologic, it is a very common symptom in persons not suffering from chronic appendicitis, and from the follow-up statistics we believe that those cases presenting a picture of enteroptosis, together with constipation and a nervous instability, should not be relegated immediately to the category of those suffering from chronic appendicitis. Constipation and chronic appendicitis are so frequently associated that it is difficult to determine which condition is the cause and which the effect.

Nausea, vomiting, belching and other gastric manifestations were very frequent. In the five cases in which there was hematemesis and in the thirty-five with pain in relation to the ingestion of food, no upper abdominal lesions were demonstrable at operation.

Since our interpretation of a chronically diseased appendix, clinically, is that of an appendix subjected to recurrent inflammation, the

history of attacks of pain in the abdomen which might have been due to appendicitis is of great importance. The total number of patients giving a definite history of previous attacks of pain is 418. In those histories in which the number of previous attacks of pain are recorded, thirty-two patients had had one attack, sixty-three had had two attacks, and 112, three or more attacks, previously. Fourteen patients complained of attacks of pain over a period of ten years; fifty-two stated



Sex and age incidence of chronic appendicitis.

the first attack had occurred from five to ten years before and 235 from one to five years, while only eighty-three had their first attack less than a year before admission.

It is significant that 145 patients who gave a history of long chronicity had an acute exacerbation necessitating immediate operation. The importance of this will be seen later in discussing mortality.

As will be noted, in eighty-two cases in this series no history of a previous acute attack could be elicited; these patients complained of a constant dull or burning pain in the right iliac fossa. This would suggest that a chronic process may be progressing without acute symptoms.

OPERATIVE FINDINGS AND PATHOLOGY

In 160 of the cases, adhesions binding down the appendix were noted. This number undoubtedly does not include those cases in which adhesions of a minor character were observed. The appendix was retrocecal in sixty-seven cases. Fecal concretions were found in twenty-two cases (4.4 per cent.). This figure is low, since the statistics usually show from 15 to 20 per cent. of the cases of appendicitis having fecal concretions.

In eight of the cases, tubo-ovarian pathology, exclusive of that of gonorrheal origin, was present. It is impossible to determine whether the initial pathologic condition was in the appendix or in the pelvic organs.

TABLE 3.—PATHOLOGIC FINDINGS IN PATIENTS OPERATED ON AS CHRONIC CASES

Lesions	Cases
Chronic catarrhal or diffuse	113
Chronic interstitial	106
Chronic obliterative	68
Chronic ulcerative	29
Chronic periappendicitis	11
Chronic tuberculous	6
Carcinoma	1
Mucocele	2
Normal	19
Total	355

Clado's appendiculo-ovarian ligament contains lymphatics which pass to the broad ligament, the pelvic connective tissue and the internal iliac glands, and in this way it is conceivable that appendicular disease may be transferred to the pelvis, as well as by direct proximity of the organs. Williams and Slater quote Waegili as believing the appendix secondarily involved in 16.4 per cent. of 896 gynecologic laparotomies.

Table 3 illustrates the pathologic findings in the patients operated on during the chronic stage. In the reports returned to the surgeons, twenty-seven different terms were used to describe the chronic lesions. We have grouped these in Table 3. A plea might well be made for a simpler and more uniform classification by pathologists.

Table 4 gives the pathologic condition of the patients operated on during an acute or subacute exacerbation but who gave a definite history of chronicity.

The majority of the pathologic reports of these 145 cases show an acute process superimposed on a chronic one. Thus, in considering the chronically inflamed appendix from the point of view of pathology, we have several types to consider. First, the appendix which shows an almost healed inflammatory lesion, but which at some previous time has gone through an acute or subacute process; second, the chronically inflamed appendix which has not begun with an acute or subacute reaction, but which shows chronic changes and which may have given rise to no symptoms; and third, either of the previous types which, by their tissue changes, have prepared the soil for an acute exacerbation.

TABLE 4.—Pathologic Findings in Patients Operated on During an Acute Attack, but with History of Chronicity

Condition	Cases
Chronic diffuse or catarrhal	
and acute catarrhal	35
and subacute catarrhal	3
and acute periappendicitis	3
and acute ulcerative	1
and acute gangrenous	1
and acute suppurative	1
Chronic interstitial	
and acute ulcerative	19
and acute interstitial	23
and acute catarrhal	14
Chronic obliterative	
and acute catarrhal	4
and acute suppurative	2
and acute interstitial	1
Chronic ulcerative	
and acute ulcerative	3
and acute gangrenous	1
Acute interstitial	11
Acute ulcerative	11
Acute suppurative and gangrenous	8
Acute suppurative	2
Acute diffuse	1
Acute ulcerative and tuberculous	1
Total	145

An attempt to classify the symptoms of the cases on a pathologic basis was found to be useless except as to the three general groups given above. We found a similar symptomatology in all the cases of chronic appendicitis, including those of tuberculosis and carcinoma of the appendix, so that no common pathologic finding can be suggested in connection with any group of clinical symptoms.

The pathologic reports in a series of 1,000 appendectomies performed during the quiescent period by Battle agree fairly well with our statistics, with the exception that he did not encounter so many cases of tuberculosis.

In three of the cases, *Oxyuris vermicularis* was found in the appendix. Whether these were causal or simply coincident it is impossible to state.

MORTALITY

Among the 355 patients operated on during the quiescent period, there was one death (0.27 per cent.). This death followed an intestinal obstruction which was secondary to a congenital fold of peritoneum, discovered at operation.

Of the 145 cases in which operation was performed during an acute exacerbation, eleven cases were perforated, and there were four deaths (2.7 per cent.).

La Roque in 600 cases of appendicitis of all types had four deaths (0.66 per cent.), and Battle in 1,000 cases of chronic appendicitis had two deaths (0.2 per cent.). Gibson had four deaths in 555 cases of chronic appendicitis (0.72 per cent.).

RELATION TO UPPER ABDOMINAL DISEASE

Chronic appendicitis and upper abdominal disease are so frequently associated that many surgeons do not think it justifiable to remove a chronically diseased appendix without exploring the upper abdomen and vice versa. Upper abdominal lesions, such as gallbladder disease and gastric and duodenal ulcer, should not be remedied without removing the appendix.

It was with a view of determining whether or not there was a relationship between disease of the appendix and of these organs that we have examined the records of seventy-six cases of gallbladder disease and eighteen cases of gastric and duodenal ulcer in which the appendix was removed at the operation for the upper abdominal disease. Of the seventy-six cases of gallbladder disease, in forty-four there was a history which pointed to previous appendiceal pathology, sixty-nine (90 per cent.) of the appendixes removed showing definite appendiceal pathology, the pathologic reports being in no wise different from the reports of the chronic cases already given. There was one case in which the appendix incidentally removed proved to be an adenocarcinoma. Of the eighteen cases of gastric and duodenal ulcer, in nine there was a previous history of appendicitis and eleven (61 per cent.) of the appendixes showed chronic pathologic changes.

It is interesting to compare the age incidence of the cases of chronic appendicitis and those of upper abdominal disease. It was found that the upper abdominal cases occur later in life than those of chronic

appendicitis, and it is possible that the diseased appendix may have played some etiologic part in the upper abdominal disease.

Heyd found the appendix diseased in 67 per cent. of the cases in which cholecystectomy was performed and in 54 and 66 per cent., respectively, of the cases in which operation was performed for gastric and duodenal ulcers. He says that "in 15 per cent. of all laparotomies there are two lesions sufficiently severe to warrant operation." Dubard found chronic appendicitis in more than 33 per cent. of 145 cases of ulcer, and explained some of the failures after gastro-enterostomy as due to operation on the one organ.

It is true, however, as we have already shown in our analysis of symptoms, that chronic appendicitis may simulate disease in the upper abdomen. In Barclay and McWilliams' series of 200 patients, 49 per cent. had pain with stomach symptoms and 80 per cent. of these were cured by appendectomy. Five of our cases, four of Heyd's and fifteen of Bassler's in which hematemesis was a symptom revealed no ulcer at an exploratory laparotomy and every case was relieved by appendectomy. Bassler explains this as a toxic effect of chronic appendicitis. Sir Berkeley Moynihan's statement that most of the ulcers of the stomach are situated in the right iliac fossa has its origin in facts similar to these.

FOLLOW-UP DATA

This material is based on the replies to the following questions:

1. How long were you incapacitated for work following operation?
2. Were the symptoms for which the operation was performed relieved?
3. If not, what symptoms still persist?
4. Have you had any further operation for these symptoms?

The follow-up was carried out either by personal interview and examination of the patient or by mail. In all, 226 patients were heard from. Gibson has suggested that the end-results might be more valuable if every case could be followed up, since many patients wholly relieved may ignore communications. We have, however, presented the statistics as we have them. It is the only method of determining whether or not we accuse the appendix without sufficient evidence. It should also be borne in mind that these patients were operated on in a teaching hospital and that many of them, especially the obscure cases, were studied primarily in the medical wards. It may thus seem to some observers that the results are better than those usually reported.

The first question was asked in order to ascertain whether the statement so frequently made to patients that they "can return to work in ten to twelve days" is correct. We found that, while an occasional

patient was able to work two weeks after operation, one patient was incapacitated for thirty-two weeks. This patient was similar to one of Gibson's cases in that he developed a fecal fistula after operation. The average time before the patient was able to go to work was five and seventy-three hundredths weeks. Thus the question of diagnosis becomes doubly important since the patient or his dependents may suffer economically.

The answers to the second question are not entirely gratifying. One hundred and eighty-eight patients were entirely relieved of their symptoms, twenty-two were partially relieved, and sixteen were unimproved or made worse.

Thus our figures are: (1) complete relief of symptoms by operation, 83.1 per cent.; (2) partial relief of symptoms by operation, 9.7 per cent., and (3) no relief of symptoms by operation, 7.07 per cent.

TABLE 5.—Complaints of Patients Who Were Partially Relieved of Symptoms

Complaints	Cases
Constipation	6
Gynecologic conditions (prolapsus, partial)	1
Occasional pain in scar	3
Diarrhea	1
Soreness in right iliac fossa	3
Tuberculous orchitis	1
Slight indigestion	2
Backache	1

The answers to question 3 throw some light on the preceding figures. We have grouped the complaints of the patients as to whether they were partially relieved or not.

Partially Relieved.—These patients have minor complaints but were relieved of the principal symptoms (Table 5).

It will be seen that the major complaint in the 9.7 per cent. of patients who were only partially relieved was constipation. Five of these patients had McBurney incisions.

Unrelieved.—This group comprises cases in some of which, at least, in our series, an incorrect diagnosis was made.

1. This patient was operated on two years later for gallstones and has since been well.

2. This patient was operated on later for floating kidney and since then has had relief of symptoms.

3. This patient was operated on later and a duodenal ulcer was found.

4. This patient has been operated on twice since appendectomy for adhesions.

5. This patient was operated on, the case being diagnosed, on later admission, as gastric neurosis.

6. This patient has a hernia following a fecal fistula.

Thus mistakes were made in not finding the cholelithiasis, the floating kidney, and the duodenal ulcer. It was also a mistake to operate in the case of gastric neurosis. Whether the adhesions were due to the original infection causing the appendicitis or whether they were postoperative we cannot say.

CONCLUSIONS

1. Few cases of chronic appendicitis are observed in the first decade.

2. There is a variation of sex and age incidence in the second and third decades.

3. The most frequent symptom is periodic pain in the right iliac fossa, and in a patient carefully studied this symptom is suggestive.

4. A normal appendix was removed in 3.8 per cent. of our cases.

5. The symptoms of the seven cases of tuberculous appendicitis and one of carcinoma did not differ in any way from the remaining cases in our series.

6. The mortality of the cases in which operation was performed during the quiescent period was 0.27 per cent., while in those in which operation was performed during the acute stage it was 2.7 per cent.

7. There seems to be a definite relation between appendicitis and upper abdominal disease and between appendicitis and pelvic disease.

8. Hematemesis may be a manifestation of chronic appendicitis.

9. The average postoperative incapacitation was five and seventy-three hundredths weeks.

10. Eighty-three and one-tenth per cent. of the patients followed up were entirely relieved, 9.7 per cent. were partially relieved and 7.07 per cent. were unrelieved.

11. The latter group was partly due to pathologic conditions unrecognized because of faulty study and exploration.

STUDIES IN EXPERIMENTAL TRAUMATIC SHOCK

VI. THE ACTION OF ETHER ON THE CIRCULATION IN TRAUMATIC SHOCK *

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This study was undertaken in an attempt to determine the effects of ether on the factors which influence the blood pressure, with special reference to the conditions as they occur in shock or circulatory failure. The fact, long known, that a patient in a condition of shock is a poor anesthetic risk was strongly brought to the attention of surgeons during the recent war, and led to an experimental study of the problem at the Laboratory for Surgical Research, A. E. F., under the direction of Lieut.-Col. W. B. Cannon. This study has been continued in the Laboratory of Physiology at the Harvard Medical School.

In the account which follows, the effects of ether on the blood pressure will be first considered, then an examination of its action on the heart, vasomotor system and blood vessels, and finally a discussion from the point of view of the circulation as a whole, together with a consideration of the changes occurring in shock.

THE EFFECTS OF ETHER ON THE BLOOD PRESSURE

The interpretation of blood pressure changes produced by ether is extremely difficult. Alterations may be produced by direct action on the heart or blood vessels or indirectly through the vasomotor or vagus centers, and by reflex effects from many parts of the body, or by various combinations of these factors. Moreover, the depressant action of the narcotic on the general body functions, such as changes in muscle tone or cell metabolism, may cause, independently of any direct action on the circulatory system, a secondary modification of the blood pressure. Partial asphyxia, produced by a reduction of the oxygen in the inspired air, by a depression of the respiration, or by the effects of a fall in blood pressure, may also be a contributory cause to any pressure changes. It is, therefore, not surprising to find reported in the literature a diversity of effects from the administration of ether, and much difference of opinion as to their cause. It is only by a study of the influence of the anesthetic on the separate parts of the circulation that significant conclusions can be reached; nevertheless, the form of the blood pressure curve, under various conditions of ether administration and under varying conditions of the patient or animal, shows instructive differences.

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* From the Laboratories of Physiology of the Harvard Medical School.

Literature.—In recent years, there has appeared in the literature a large number of clinical observations on the effects of anesthetics on the blood pressure. It will be sufficient to mention here only a few of the most important papers, since the experimental work performed on animals gives us more reliable information. Most of the earlier measurements of blood pressure in man under anesthetics were made for a comparison of the effects of ether and chloroform, and it is now well established that the administration of chloroform results in a definite decrease in the blood pressure. The effect of ether is not so clear. The earliest direct measurements of blood pressure in man during ether anesthesia were made by Blauel.[1] In a series of 100 patients, a large percentage showed a rise in blood pressure; and it was only at the end of the operation that there was any tendency to a fall. The observations of Kaefer,[2] Holz,[3] Mummery,[4] Walton,[5] Blumfeld,[6] Fairlee,[7] and Marshall,[8] show that there is either a slight rise in pressure during the administration of ether or no change. McWilliam [9] reports that ether administration results in a gradual but slight fall in pressure. The observations of Cook and Briggs [10] indicate that ether causes a transitory initial rise followed by a slight fall in pressure. Similar conclusions are reached by Cushny [11] (p. 205).

While it appears to be generally recognized that patients in a condition of shock or circulatory collapse are very susceptible to the effects of ether and chloroform, no observations on the blood pressure changes resulting under these conditions have been found in the literature. Marshall,[8] working with the severely wounded at the front, found that, after ether anesthesia, collapse frequently occurred; while under nitrous-oxid and oxygen there was but slight reduction in the blood pressure. In addition, there are a considerable number of clinical observations showing the superiority of nitrous oxid anesthesia over that of ether in conditions of shock, and these testify to the sensitive condition of the

1. Blauel: Beitr. z. klin. Chir. **31**:271, 1901.

2. Kaefer: St. Petersb. med. Wchnschr. **10**:233, 1893; referred to in Zentralbl. f. Chir. **21**:58, 1894.

3. Holz: Beitr. z. klin. Chir. **97**:177, 1915.

4. Mummery: Lancet **1**:696, 776, 846, 1905.

5. Walton: Lancet **2**:17, 1905.

6. Blumfeld: Practitioner, Jan.-June, 1909, p. 231.

7. Fairlee: Lancet **1**:603, 1914.

8. Marshall: Proc. Roy. Soc. Med., Sect. on Anesthetics **10**:17, 1916-1917.

9. McWilliam, referred to in Patton: Anaesthesia and Anaesthetics, Ed. 2, Chicago, Cleveland Press, 1906, p. 100.

10. Cook and Briggs: Bull. Johns Hopkins Hosp. **11**:451, 1903.

11. Cushny: Text Book of Pharmacology and Therapeutics, Ed. 7, Philadelphia, Lea & Fabiger, 1918.

circulatory system to the administration of ether. Cannon[12] reports a series of observations on the blood pressure and alkali reserve in severely wounded men, under ether, before and after operation. It was found that the blood pressure fell during operation and that, in general, the greater the fall in blood pressure the lower the original carbon dioxid capacity of the blood. This observation is of interest in connection with experimental work[13] showing that the degree of acidosis is a direct indication of the circulatory condition, i. e., the extent of shock.

To summarize, the evidence indicates that ether, properly administered to normal subjects, produces no fall in blood pressure or may even cause a transitory increase during the early stages of its administration; while in shock, circulatory collapse frequently occurs.

It is a matter of common experience in the physiologic laboratory that animals may be kept under ether anesthesia for a number of hours without any appreciable drop in blood pressure. Knoll,[14] in 1878, reported a fall in pressure from ether and chloroform in rabbits. Similar observations were made by Cushny[15] in rabbits and dogs, by Witte[16] in rabbits, by Pick[17] in dogs, and McWilliam[18] in cats. Kionka[19] and Elfstrand[20] found practically no change in the blood pressure in rabbits under ether anesthesia. Similar conclusions were reached by Bock[21] from a series of experiments on isolated heart-lung preparations from rabbits. Csiky[22] reports, from experiments on dogs, that ether raises the blood pressure by stimulation of the heart. Düplay and Hallion[23] made a careful study of the fluctuations of blood pressure occurring under chloroform and ether anesthesia, and an attempt was made to determine the cause of these variations by simultaneous measurements of the changes in volume of the kidney. The conclusion was reached that the first rise in the blood pressure curve was due to vasoconstriction, while the fall in pressure which followed was due to a decrease in the

12. Cannon, W. B.: Acidosis in Shock, Hemorrhage and Gas Infection, J. A. M. A. **70**:531 (Feb. 23) 1918.

13. Cannon, W. B., and Cattell, McKeen: Studies in Experimental Traumatic Shock. V. The Critical Level in a Falling Blood Pressure, Arch. Surg. **4**:300 (March) 1922.

14. Knoll: Philipp: Sitzungsb. d. k. Akad. Wissensch., Math.-Naturw. Cl., Wien. **78**:223, 1878.

15. Cushny: Ztschr. f. Biol. **28**:365, 1891.

16. Witte: Dissert. Göttingen, 1898.

17. Pick: Arch. f. exper. Path. u. Pharmakol. **42**:399, 1899.

18. McWilliam: Brit. M. J. **2**:831, 890, 948, 1890.

19. Kionka: Arch. f. klin. Chir. **1**:339, 1895.

20. Elfstrand: Arch. f. Path. u. Pharmakol. **43**:435, 1900.

21. Bock: Arch. f. exper. Path. u. Pharmakol. **41**:173, 1899.

22. Csiky: Magy. droosi Arch. **7**.

23. Düplay and Hallion: Arch. gen. de méd. **9**:130, 1900.

activity of the heart. Cushny, in an early edition of his textbook,[24] states that the evidence indicates that the first effect of ether is a depression of the heart, resulting in a fall in blood pressure, which in some instances may be compensated for by a vasoconstriction from reflex stimulation of the vasomotor center, so that the blood pressure may rise while the heart is slowed. The statement is made in a report of the Medical Research Committee of Great Britain[25] that experiments with animals under ether anesthesia have shown that, when a state of acidosis has been produced, the administration of ether in but slight excess of the amount needed to maintain anesthesia readily induces a fall in blood pressure. Other than this, no reference has been found bearing on the question of the effect of ether in experimental shock.

It will be noted that there is a slight discrepancy in the conclusions reached by different observers, a few reporting no change in blood pressure under ether anesthesia but the majority finding some fall. In the light of research on the action of ether on the separate parts of the circulatory system, this is not surprising, the blood pressure being dependent on the summation of a number of factors, some of which tend to increase it and others to have the opposite effect. Moreover, there is the factor of individual variation, perhaps dependent to a considerable extent on the condition of the animal. Any one who has worked on the vasomotor reactions is aware how great these variations may be. The method and rate of administration have an important influence on the result. These factors alone in certain individual animals will determine whether the net result is a fall or a rise in blood pressure.

Method.—Following is a general outline of the technic employed in obtaining the blood pressure records. In addition, there were several special methods used and modifications of procedure, which will be described in connection with the particular experiment in which they were employed. In all the later experiments, cats were used; while many of the earlier ones, which were done at Dijon, France, were performed on dogs and rabbits. Various anesthetics were used, depending on the point to be investigated. Usually, it was found most convenient and satisfactory to keep the animals under light ether anesthesia, which could be entirely removed just before making a test to determine the effects on the blood pressure of inspiring strong ether. In other cases, ethyl carbamate (urethane) was used, and, in still others, the cats were decerebrated under preliminary ether anesthesia.

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24. Cushny: Text Book of Pharmacology and Therapeutics, Ed. 6, 1915, p. 201.

25. Medical Research Committee: Report of Special Investigative Committee on Surgical Shock, No. 7. Acidosis and Shock, 1918, p. 12.

Blood pressure records were obtained from the carotid artery of the animal by means of an ordinary mercury manometer and kymograph. Usually, the drum was run at a slow rate, so that pressure changes covering relatively long periods might be conveniently recorded; but in other cases, when changes in the heart rate were to be determined, a more rapid rate was employed. Various methods of ether administration were used at different stages of the experiments. The following was found to be the most satisfactory: A constant stream of air, from a source of pressure, was passed through an ether bottle provided with a short-circuiting arrangement, so that all, part, or none of the air bubbled through the ether. This was conducted by means of rubber tubing to the animal through a T-shaped cannula in the trachea, the other end of which was connected to a Müller water valve. Usually, the animal was allowed to breath naturally, but a motor-driven interrupter of the air current was placed between the source of compressed air and the ether bottle so that in case artificial respiration was desired it was readily available. The advantage of this method is that the ether can be administered without rebreathing, and without in any way disturbing the animal, all the other conditions remaining constant. The concentration of the ether in the inspired air was not measured, but the conditions in the whole series of experiments were practically uniform and there is no reason to suppose that there was wide variation in the ether concentrations. In any case, small variations would not interfere with the comparisons, as the depth of anesthesia, as indicated by the disappearance of reflexes, was used as a standard, and this probably corresponds closely to the concentration of ether in the blood, regardless of the slight differences of concentration in the inspired air. While the ether was being given during a test, repeated observations were made on the eye reflex by a gentle and uniform tap at the inner corner of the eyelids and, at the time when the reflex had just disappeared, the blood pressure noted. Thus it was possible to make comparisons of the blood pressures at a given depth of anesthesia in different animals, and in the same animal under different conditions. In making a test, the ether was turned on suddenly and was of such strength that it would cause a fairly rapid disappearance of the reflexes, and, if continued long enough, would cause death. It having been abundantly demonstrated that a condition of light anesthesia could be brought about with practically no effect on the blood pressure of the normal animal, the object of these experiments was to study not the effects of light anesthesia but rather the acute effects of concentrations of ether having a definite influence on the blood pressure. In most of the experiments, the administration of ether was continued nearly to the point where the life of the animal was endangered. A note was made on the blood pressure record at the instant the eye reflex could no longer be obtained,

and also at the point where, after a given period of time, the ether was discontinued.

In nearly all cases, observations were made on the effect of ether on the blood pressure early in the experiment, when the animal was in good condition, and again later, after the development of shock, all conditions being kept as nearly uniform as possible throughout the

ANALYSIS OF BLOOD PRESSURE CHANGES FROM ETHER IN A SERIES OF TWENTY CATS ANESTHETIZED UNTIL THE EYE REFLEX DISAPPEARED

Primary Drop in Pressure Followed by a Rise (12 Cases)

	Blood Pressure		
Experiment	At Start	Fell to	As Reflex Disappeared Rose to
48	130	100	156
49	125	90	122
51	160	135	175
52	145	90	120
56	115	80	110
57	98	45	100
59b	115	88	115
68	70	48	84
69	120	90	115
70	140	125	145
71	110	80	100
72	135	125	130
Average	122	91	123

No Rise Following Primary Drop in Blood Pressure (5 Cases)

	Blood Pressure	
Experiment	At Start	Fell to and Remained at
53	118	75
60	126	126
64	155	135
65	145	130
67	125	115
Average	134	116

Primary Drop in Blood Pressure Followed by Further Fall (3 Cases)

Experiment	Blood Pressure At Start	Comment
50	132	Rapid fall toward zero
58	115	Rapid fall toward zero
66	165	Rapid fall toward zero

experiment. In many cases, the animal spontaneously developed a condition typical of shock after having been kept anesthetized for a number of hours; in others, the condition was artificially hastened by interference with the circulation. This was done by a method, previously described,[13] by which the intrapericardial pressure is increased, thus interfering with the normal return of the blood to the heart and reducing the blood pressure. The reduction of the pressure to 60 mm. of mercury for one hour was usually sufficient to produce symptoms of shock.

The Effect of Ether on the Blood Pressure of Normal Cats.—Almost invariably there is a sharp primary fall in blood pressure at the beginning of the ether administration, which, in the majority of cases, is temporary and is followed by a gradual recovery as the anesthesia deepens. This rise may reach a greater height than the original blood

pressure or it may remain somewhat below this level. In a series of twenty experiments on cats, summarized in the accompanying table, this type of reaction occurred in 60 per cent. of the cases. A somewhat extreme example is illustrated by the record presented in Figure 1 *a*. In these cases, the average drop in blood pressure was 32 mm. of mercury. This drop, however, is temporary, the pressure being back to normal by the time a degree of anesthesia was reached sufficient to cause a disappearance of the eye reflex. This degree of anesthesia was

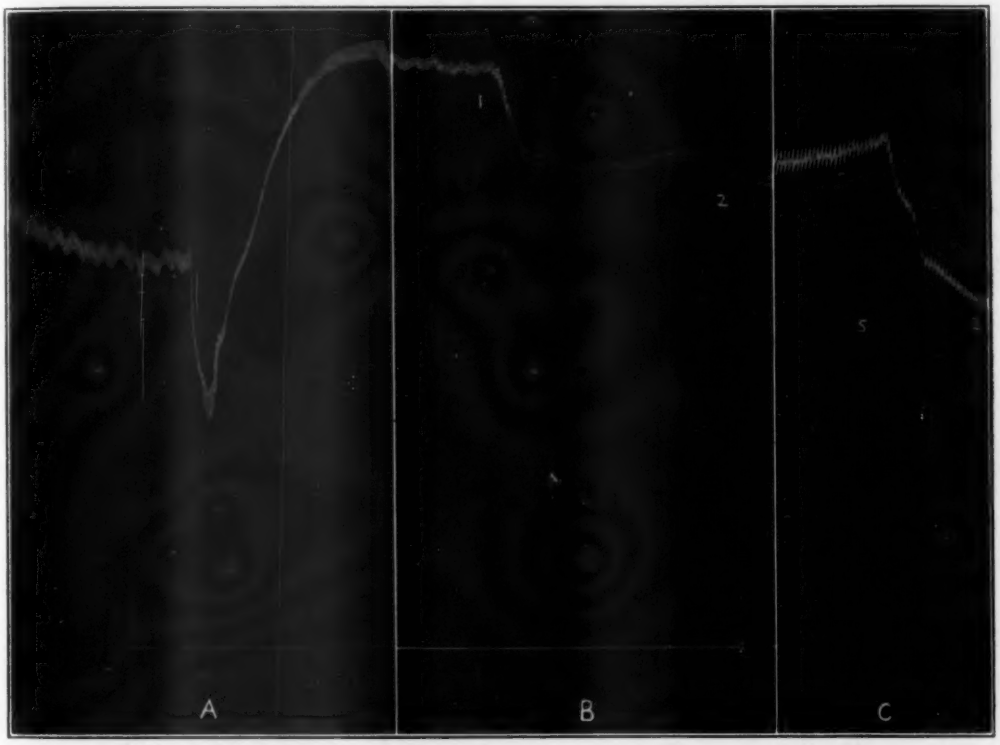

Fig. 1.—Examples of the effect of ether on the blood pressure of cats: *A*, record from Experiment 85: *a*, ether on; *b*, reflex gone (ninety-five seconds); *c*, ether off (140 seconds); *B*, record from Experiment 69: 1, ether on; 2, ether off (four minutes); *C*, record from Experiment 50: 1, ether on; 2, reflex gone and ether turned off.

obtained in from two to four minutes. If the administration of ether was continued longer, usually after about five minutes a second fall in blood pressure occurred which quickly caused the death of the animal.

The second class of cases shown in the accompanying table includes those animals in which the primary fall in blood pressure was not followed by a rise, but continued at the new lower level. It will be noted that in these cases the fall in pressure was not very marked, so

that, although there was no recovery, the blood pressure was still at a high level when the eye reflex disappeared. An example of this type of reaction is shown in Figure 1 *b*.

In only three out of the series of twenty cats was there a failure to maintain a normal blood pressure, as is shown in the table. In these three cases, there was a continued fall in pressure, so that the ether had to be discontinued before deep anesthesia was attained. This is the type of blood pressure change found, to a more marked degree, in shocked animals. It is illustrated in the record shown in Figure 1 *c*. In these cases, the animals had previously undergone severe operation; in one case, decerebration, in the other two, chest operations; and it is probable that this condition of ether sensitiveness did not exist previous to these procedures.

In some cases, as the depth of anesthesia increases, the respiration may become gradually more shallow, even before the eye reflex disappears. It seemed possible that part of the recovery of the blood pressure which occurs during the administration of ether might be accounted for by an asphyxia produced in this way. That this factor may influence the extent of recovery is indicated in a few experiments in which there was a slightly less marked recovery with artificial respiration. Frequently, however, the rise obtained under regular artificial respiration is equal to that under natural respiration.

By giving the ether gradually, it is always possible, in the normal animal, to attain a depth of anesthesia where the eye reflex is abolished, without the intervening drop in blood pressure. If ether is inhaled while the animal is anesthetized, the effect on the blood pressure is very much less than when it is given to an animal that is not already under the influence of ether. Similarly, the fall in pressure caused by the intravenous injection of ether is much less in the deeply anesthetized animal. In eight out of nine cats tested with ether injections, this was true. These animals repeatedly gave greater drops in pressure when the anesthetization was light. For example, in Experiment 53, in six trials there was an average fall of 19.3 mm. following the injection of 1 c.c. of a saturated solution of ether in physiologic solution of sodium chlorid at room temperature (about 8 per cent. ether) during light anesthesia; whereas, with deep etherization, a similar series of six injections caused an average fall of only 8.3 mm., the original pressure being the same in each case.

The significance of these pressure changes will be considered later in relation to the action of ether on the separate parts of the circulatory system.

The Effect of Ether on the Blood Pressure of the Shocked Animal.—In these experiments, methods were used in obtaining the records and in administering the ether similar to those described for the normal

animal. In fact, in most cases, records of blood pressure showing the effects of ether before and after shock were obtained from the same animal, all the external conditions remaining constant. The effects on the blood pressure are strikingly different after shock has developed. A typical result is illustrated in Figure 2. Just as in the normal animal, the first effect is a sharp drop in pressure, but this is not followed by a recovery; instead, there is a further fall which rapidly approaches zero, often before the eye reflex disappears. Even when ether is administered more gradually and to a much less degree, the pressure falls, though

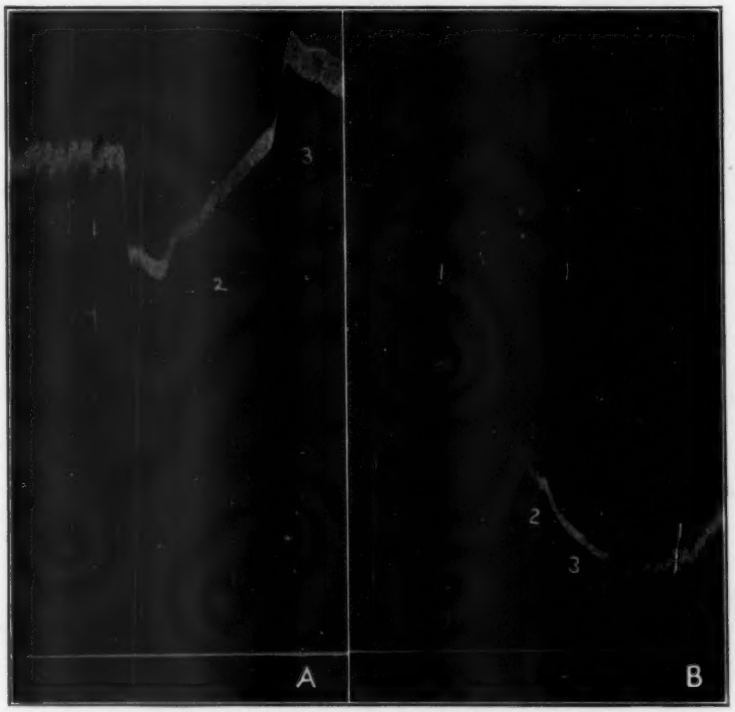

Fig. 2.—The influence of strong ether on the blood pressure before and after shock: 1, ether on; 2, eye reflex gone; 3, ether off. *A*, ether effect before shock; *B*, a record taken three hours later after shock had developed, but under otherwise similar conditions.

not so abruptly. In a series of over fifty animals this increased sensitiveness to ether was so constant that it is unnecessary to tabulate the individual experiments. Regardless of how the ether is administered, the blood pressure in the shocked animal will show a considerable decrease at the point where the eye reflex is just obliterated; whereas, in the normal animal, the pressure is but slightly, if at all, below that before anesthetization. The significance of this change in the effect of ether will be discussed later.

The Effect of Nitrous Oxid-Oxygen Anesthesia on the Blood Pressure.—In the course of our work at the Dijon laboratory, some incidental observations were made by Dr. Cannon and myself on the effects of nitrous oxid-oxygen anesthesia on the blood pressure of shocked animals, which may be briefly mentioned here. It was found possible to induce in the shocked animal a full degree of anesthesia without any fall in blood pressure. In the same animal, the inhalation of ether to the same depth of anesthesia, i. e., until the eye reflex disappeared, would cause the usual drop in blood pressure. The absence of circulatory depression with nitrous oxid and oxygen is true only when they are administered in the most favorable proportions, the best results being obtained by the use of the largest proportion of oxygen com-

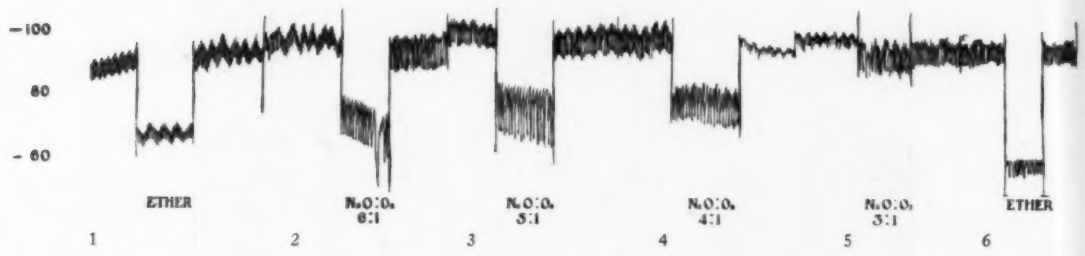

Fig. 3.—Comparison of the effect of ether and of nitrous oxid and oxygen in a shocked animal. In each case, the anesthetic was given until the eye reflex just disappeared, when the record was taken. 1, Blood pressure drop produced by ether; 2, blood pressure drop produced by nitrous oxid and oxygen, 6:1; 3, blood pressure drop produced by nitrous oxid and oxygen, 5:1; 4, blood pressure drop produced by nitrous oxid and oxygen, 4:1; 5, blood pressure drop produced by nitrous oxid and oxygen, 3:1; 6, blood pressure drop produced by ether.

patible with the production of the desired depth of anesthesia. This result can usually be obtained with a mixture of from three or four parts of nitrous oxid to one part of oxygen. Higher concentrations of nitrous oxid may result in a fall in blood pressure nearly as great as that from ether. In some animals, it is not possible to get complete abolition of the eye reflex without some fall in pressure, but this fall is always less than that resulting from ether (Fig. 3).

THE EFFECTS OF ETHER ON THE HEART

Literature.—The importance of the influence of anesthetics on the heart was early recognized, and a considerable amount of careful experimental work has been done on the action of chloroform and ether.

much of which was carried out from the point of view of determining the relative toxicity of these two drugs. Knoll,[14] in 1879, made a comparative study of the effects of chloroform and ether on the circulation in rabbits, from which he concluded that ether in moderate doses was limited in its influence to the vasomotor system, while chloroform had a direct injurious action on the heart. Diaballa [26] was the first to make a quantitative study of the relative toxicity of different anesthetics on the heart. He transfused the isolated frog heart with solutions of sodium chlorid, to which were added varying amounts of the drugs studied. A chloroform concentration of 0.126 per cent. was sufficient to bring the heart to a standstill within two and a half minutes, while with ether it was necessary to use a concentration of 2.84 per cent. to produce the same effect. Ether in a concentration up to 0.235 per cent. was without influence on the heart. In perfusion experiments carried out by Osthelder [27] on the frog heart, it was found that the employment of either chloroform or ether resulted in a depression of its function, the effects being much more marked with chloroform. If the amount of ether was sufficiently small, stimulation of the heart resulted. McWilliam [18] reports a series of experiments on cats in which he obtained simultaneous records of the blood pressure and of the auricular and ventricular contractions, and recorded the variations produced by the inhalation of ether and chloroform under artificial respiration. It was found that with either of these substances, when given in an amount sufficient to cause a disappearance of the corneal reflex, there was a drop in the blood pressure along with a decrease in the functional activity of the heart. The conclusion was reached that chloroform depresses the heart directly, while the effect from ether is secondary to a lowered blood pressure. The grounds for the conclusions regarding the effects of ether are not evident from the results presented; the fall in pressure might with equal probability be interpreted as being secondary to the weakened heart action. In the isolated heart-lung preparation of rabbits, Bock [21] observed little or no drop in pressure from ether administered in the inspired air, whereas the administration of chloroform resulted in a marked drop. The concentrations of the anesthetics used are not given. Muehlberg and Kramer [28] studied the effects of ether and chloroform injected directly into the circulation. Both substances caused a rise in blood pressure when introduced into the carotid, but, when injected intravenously, a fall in pressure. It was concluded that ether injected intravenously is more toxic than

26. Diaballa: Arch. f. exper. Path. u. Pharmakol. **34**:147, 1894.

27. Osthelder: Diss. Würzburg, 1896.

28. Muehlberg, William, and Kramer, S. P.: The Action of Toxic Doses of Ether and the Influence of Amyl Nitrite Thereon, J. A. M. A. **48**:2093 (June 22) 1907.

chloroform and that the fall in pressure is due to a direct depressant action on the heart. Tunnicliff and Rosenheim [29] transfused the isolated mammalian heart with Locke's solution. The addition of 0.01 per cent. of chloroform had a noticeable influence, while 0.10 per cent. brought the heart to a standstill. Ether was much less effective, causing only a temporary irregularity and slowing of the heart. However, concentrations of ether were used only up to 0.20 per cent., which were based on the determinations of Franz,[30] who found in the blood of etherized animals only 0.05 per cent. of ether. More recent determinations have indicated that this figure is too low. Nicloux [31] gives from 0.13 to 0.15 per cent. of ether as average figures for the amount present in the blood during deep anesthesia. Storm van Leeuwen [32] found that at the point where the eye reflex disappeared the percentage of ether in the blood by weight was 0.18. Additional experiments by Schram, Storm van Leeuwen and van der Made [33] showed that a concentration of from 0.101 to 0.212 per cent. was necessary before any harmful effects on the circulation were evident, and that the complete arrest of the heart occurred with a blood ether content of 0.250 per cent. With the removal of vagus influences, and by maintaining artificially an adequate circulation, the minimum lethal dose rose to 0.553 per cent. Since drops in blood pressure were obtained with concentrations of ether insufficient to affect the isolated heart, the conclusion was reached that the fall in pressure is due to an influence on the vasomotor and vagus centers. Loeb [34] also investigated the action of ether on the isolated cat heart, perfusing with a blood-sodium chlorid mixture. He found 0.133 per cent. to be the minimum harmful dose, and 1.7 per cent. the minimum lethal dose. Perfusion experiments on the isolated turtle heart were carried out by Vernon.[35] Ringer's solution, containing various concentrations of ether and chloroform, was perfused through the aorta, and the effect on the extent of contraction recorded. In concentrations of ether above 0.10 per cent., the heart was affected, a 0.20 per cent. solution reducing the extent of the contractions to 75 per cent. of their original value. Chloroform was about twenty-five times as effective.

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29. Tunnicliff and Rosenheim: Proceedings of the Physiological Society, J. Physiol. **29**:15, 1903.

30. Franz: Dissert, Würtzburg, 1895.

31. Nicloux: Les Anesthesique généraux au point de vue Chimico-physiologique, Paris, 1908.

32. Storm van Leeuwen: Arch. f. d. ges Physiol. **165**:594, 1916.

33. Schram, Storm van Leeuwen and van der Made, Arch. f. d. ges Physiol. (Pflüger's) **165**:123, 1916.

34. Loeb: Arch. f. exper. Path. u. Pharmakol. **52**:459, 1905.

35. Vernon: J. Physiol. **45**:194, 1910.

The experimental evidence briefly summarized above strongly favors the assumption that ether, in the concentrations present in ordinary anesthesia, causes a decrease in the efficiency of the heart, which might account for any fall in arterial pressure occurring under ether anesthesia. In the course of this investigation, a few experiments were made on the action of ether on the heart. Though confirmatory of the results obtained by previous workers, they may be worth recording here. Information was gained in three ways: from experiments on the heart volume, from the contractions and output of the cold-blooded heart, and from blood pressure changes.

The Effect of Ether on the Tonus of the Heart.—In order to determine what part the heart played in the blood pressure changes induced by ether, it was of interest to know what changes occurred in the heart under the experimental conditions described in the first section. To do this, heart volume records were made, using the pericardial sac as an oncometer. This method has been employed by a number of the older investigators for the examination of the systolic output under various conditions, and is described in a paper by Johansson and Tigerstedt.[36] Schäfer [37] states that the method has been found unsuitable on account of the elasticity of the pericardium and interference with the action of the heart by the surrounding fluid. These objections doubtless hold for the examination of the systolic output, but do not apply to the use of the method for investigating the changes in the heart volume occurring over a period of time independently of the individual contractions. The advantage of the method over others is its extreme simplicity. A glass cannula is inserted into a small opening in the pericardium and tied in place. It is connected directly to a volume recorder, the volume changes of the heart being transmitted through some fluid (a 6 per cent. gum-salt solution was found satisfactory). The chest can be closed and the animal allowed to breathe naturally after the operation is completed. Ether was administered through a tracheal cannula in the usual manner.

In this way, heart volume records showing the effects of ether were obtained in eleven cats, all of which gave consistent results as often as the inhalation of ether was repeated. From the beginning of the administration of ether, there is a relaxation of heart tone, as indicated by an increase in volume. This becomes progressively greater as the anesthesia becomes deeper, the maximum dilatation being reached only with the death of the animal. This is true regardless of the pressure changes which may occur as a result of the ether, the heart volume increasing through the primary fall and the subsequent recovery. In

36. Johansson and Tigerstedt: Skand. Arch. f. Physiol. **1**:331, 1889.
37. Schäfer: Text Book of Physiology, 1900, Vol. 2.

one unusually resistant animal, it was possible to give ether in relatively strong concentration with practically no effect on the blood pressure until after the eye reflex had disappeared. The heart volume record registered the usual increase, giving further evidence that the changes recorded represent a true change of heart tone independent of any blood pressure changes. A record taken from this animal is given in Figure 4. A second tracing is illustrated in Figure 5, taken from the same experiment, with the animal under artificial respiration and the chest open, showing that the change is not dependent on any effect on the respiration or tone of the chest muscles. Similar results are obtained after cutting

Fig. 4.—Effect of ether on the heart volume: top record, blood pressure with mercury manometer; middle record, heart volume taken with a volume recorder, a rise indicating an increase in volume; bottom record, zero blood pressure and signals: 1, ether on; 2, eye reflex gone; 3, ether off after two and one-half minutes.

both vagi, although the blood pressure changes and increase of heart volume may be less marked under these conditions.

A similar but very transitory effect on the heart volume is produced by the intravenous injection of small amounts of ether dissolved in Ringer's solution. This is illustrated in Figure 6.

Since the method does not exclude effects which might be produced by volume changes of the auricles and entering veins, it might be argued that the effects recorded are due to a passive filling of these parts. This is made quite improbable from the facts that (*a*) the effect is inde-

pendent of pressure changes; (*b*) it is not necessarily accompanied by a slowing of the heart, and (*c*) the administration of ether is accompanied by a peripheral constriction (to be demonstrated later). That the increases in heart volume registered are not due to the passive effects resulting from the fall in arterial pressure or to a dilatation of the blood vessels can be demonstrated by bringing about these changes artificially through the occlusion of certain areas of the circulation. The removal from the carotid of a clip which has been present for some

Fig. 5.—Tracing taken from the same animal as in Figure 4, but with the chest widely opened and under artificial respiration. Top record, heart volume, the rise representing an increase in volume; middle record, blood pressure with mercury manometer; bottom record, zero blood pressure and signals showing time of ether administration.

minutes results in a decrease of the peripheral resistance with a consequent fall in blood pressure; but the change in the heart volume record is just the opposite from that caused by ether; that is, there is a small decrease.

The question may be raised as to whether the relaxation of heart tone is accompanied by a decrease in the output of blood. That such a

relationship holds is indicated by the evidence. Certainly it is true in the isolated heart of the cold-blooded animal, where, in experiments presently to be described, ether causes a marked decrease in tone and at the same time reduces the extent of contraction and the output per minute. Moreover, the effects on the volume are similar to those produced by vagus stimulation, carbon dioxid and other agents which are known to decrease the heart output. The progressive character of the dilatation, as the anesthesia deepens, until the time of death, is also an indication that the change is one of continuously decreasing output.

The Effect of Ether on the Isolated Cold-Blooded Heart.—In order more directly to observe the cardiac effects of ether in the concentrations present in the blood, some tests were made on strips of muscle taken

Fig. 6.—Effect of intravenous injections of ether on the heart volume. Record shows the effects of three successive injections of 1 c.c. of physiologic solution of sodium chlorid saturated with ether at room temperature. Upper record, blood pressure with mercury manometer; middle record, zero blood pressure; lower record, heart volume, a rise representing an increase in volume.

from the auricle of the turtle heart. Records were obtained of the rate and extent of contraction by simply attaching one end of the auricular muscle to a heart lever and the other to a glass rod which extended down into a beaker of Ringer's solution to which the various concentrations of ether could be added.

When first removed from the animal, the strips of auricular muscle always showed marked rhythmic changes in tone. On changing the Ringer's solution to one containing 0.18 per cent. ether by weight, there

was a gradual but immediate fall in tone and the rhythmic variations ceased, as shown in Figure 7. When a change was made to a fresh solution without ether, there was a rapid recovery of tone and resumption of the periodic contractions. It will be noted that there is some decrease in the extent of the contractions. In some cases, an exposure to this concentration of ether for twenty minutes resulted in a decrease to about half of the original amplitude. In experiments on the isolated frog heart, later to be reported in detail, it was found that ether, used in this concentration, produces a marked reduction in output, along with a decrease in the extent of the contractions.

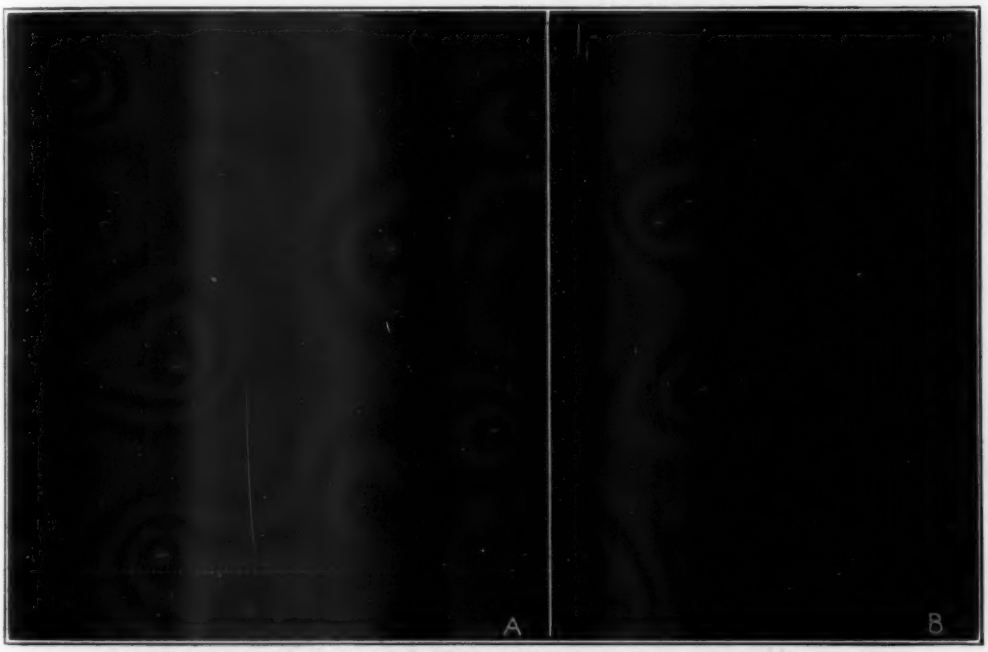

Fig. 7.—The effect of a weak ether solution on the isolated auricle of the turtle heart: *A*, record taken from auricle in Ringer's solution; *B*, record taken immediately after changing to a solution containing 0.18 per cent. of ether by weight; upper record, auricular contractions; lower record, time in five second intervals.

These results are confirmatory of a number of observations previously recorded in the literature. They are of interest in connection with the work of Storm van Leeuwen,[32] referred to above, who found that in the cat the eye reflex disappeared when the concentration of ether in the blood reached 0.18 per cent. by weight. This concentration of ether is sufficient in the cold-blooded heart to cause a decrease in tone and extent of contraction, and it is probable that in the cat the effect, at a higher

temperature, would be even greater and might thus account for the fall in blood pressure occurring in ether anesthesia.

The Effect of Ether on the Heart Deduced from Blood Pressure Changes.—An examination of the blood pressure effects from ether, in connection with the conditions of peripheral tone, reveals further information. Turning back to the blood pressure records of the normal cat (Fig. 1), it will be remembered that there is a sharp initial drop in pressure, followed, in most cases, by recovery. Simultaneous plethysmograph and perfusion experiments on the hind leg, described in the section following, show that during this drop there is no dilatation of the blood vessels whatever—indeed there may be constriction. The

Fig. 8.—The effect of cutting both vagi on the fall in pressure produced by ether in a shocked animal; *A*, ether fall produced before cutting vagi; *B*, the same after cutting vagi; 2 marks the time when the eye reflex could no longer be elicited, and 3, after four minutes of ether inhalation.

pressure fall must, therefore, be due to an influence on the heart. The later drop in pressure occurring during very deep etherization may be due in part to vasomotor effects; but this does not concern us here.

The vagus center undoubtedly modifies to some extent the changes in blood pressure resulting from the administration of ether. Knoll [14] observed that animals with cut vagi were able to withstand much larger doses of ether than the animals in which the vagi were intact. Schram, Storm van Leeuwen, and van der Made [33] found that it required an average concentration of 0.31 per cent. of ether in the blood to bring the

heart to a standstill in animals under atropin, or with cut vagi; while, in the intact animal, the heart was brought to a standstill by a concentration of 0.25 per cent. An example of the effect of the same dose of ether before and after cutting the vagi in a shocked animal is given in Figure 8. A similar effect was observed on the respiration, animals with cut vagi continuing to breathe for a longer period under strong ether inhalation.

In the transitory effect produced by the injection of small amounts of ether into a vein, there is always a primary drop in blood pressure which may be followed by a rise above normal. In this case, the heart is reached before the vasomotor center or peripheral vessels. On the other hand, if the injection is made into the carotid artery toward the head, the relations are reversed: the vasomotor center is first reached, resulting in a rise in pressure, followed later by a fall. The time relations here indicated strongly support the idea that the fall in pressure is due to an influence on the heart. These experiments will be considered in greater detail in connection with the study of the vasomotor effects of ether.

The Effect of Ether on the Heart in Shock.—No references have been found to experimental work on the effects of anesthetics on the heart in shock. There is much evidence, however, that the function of the heart is in no way depressed in this condition, and that it is still capable of doing the normal amount of work.[38] While direct experimental examination as to this question has not been made, no indication of an increased ether effect on the heart has been observed in the course of these experiments. The investigation of the problem is made difficult by the marked drop in blood pressure resulting from the administration of ether in shock. This interferes with plethysmograph records and also with the nutrition of the heart, thus causing a depression independently of the direct action of ether on the organ. The administration of ether unquestionably results in an earlier cessation of the heart beat in the shocked animal, but this may well be due to the secondary effect of the low blood pressure. There is, in fact, some evidence that the heart may become more resistant under the conditions of those experiments in which ether is repeatedly given over long periods. In a number of animals in which the blood pressure had been low for some hours and a considerable additional fall was not possible, the heart was found to be exceedingly resistant to outside influences. Ether, given in high concentration over long periods, had but little effect, while earlier it would rapidly cause the pressure to fall to zero, the death of the animal ensuing. Perfusion experiments now being carried out on the isolated frog heart indicate that a certain tolerance may be acquired. If the

38. Cannon: Traumatic Shock, New York, D. Appleton & Co., in press.

perfusion is continued long enough, the heart will recover from a toxic concentration of ether, which at first produces a marked depression. Similar observations were made by Kuno [39] and by Ransom,[40] in the perfusion of the frog heart with alcohol. The blood pressure experiments mentioned earlier show that the effect of a given amount of ether is very much less when the animal is already under the influence of ether. This, however, may be due to an adaptation of the animal as a whole, rather than to a specific influence on the heart. There is no reason to suppose that the increased tolerance to ether bears any relationship to the changes occurring in shock; on the contrary, it is due rather to changes brought about by the prolonged administration of ether.

Modification of the Effects of Ether on the Circulation by Epinephrin.—Interesting light is thrown on the problem in the change produced by epinephrin on the reactions of the shocked or "sensitive" animal. Early in the research, it was noted that certain animals which had been resuscitated by an injection of this substance into the carotid artery after an overdose of ether lost a large part of the sensitiveness to ether which they had previously exhibited. Further experiments have established the fact that this was due to an influence on some part of the circulation, probably the heart. In all, fourteen cats were examined for the effect of epinephrin on the circulatory depression produced by ether. In some of these cases, it was given as a restorative measure after an excessive dose of ether; in others, injections were made for the purpose of comparing the reaction to ether before and after the injection. The injections were made directly into the circulation in fairly large doses (from 0.1 to 1 mg.). The immediate effect was, of course, a prolonged increase in blood pressure, followed by a fall, usually to less than the original level. In a number of instances, ether could be administered at this point in high concentration without any effect whatever on the blood pressure; whereas, a few moments earlier, before the injection of epinephrin, a considerably smaller dose of ether would cause the pressure to fall to zero. In other cases, the protection was not so complete; but in all but one of the animals there was a considerable reduction in the ether effect. This one exception showed no appreciable change in the ether fall. The original sensitiveness to ether only gradually returns, in most cases the influence of the epinephrin still being apparent an hour after its injection. This is true both for inhaled ether and for ether given by intravenous injection. In Experiment 39, the intravenous injection of 1 c.c. of a saturated solution of ether in Ringer's solution caused a drop of 26 mm. in the arterial pressure; but, after the injec-

39. Kuno: Arch. internat. de pharmacol. **77**:206, 1914.
40. Ransom, F.: J. Physiol. **53**:141 (Sept.) 1919.

tion of 0.3 mg. of epinephrin, this amount of ether caused no fall whatsoever. One hour later, there was some return to the sensitive condition, the injection of 1 c.c. of the ether solution resulting in a 9 mm. drop in pressure. The influence of epinephrin on the blood pressure drop, caused by inhaled ether in a sensitive dog, is illustrated in Figure 9. The first record shows the effect of a rather light dose of ether inhaled until the eye reflex just disappeared. This animal had gradually become sensitive to the effects of ether through the course of the experiment, this amount of ether having no influence on the blood pressure earlier in the day. Shortly after this record was obtained, the animal was

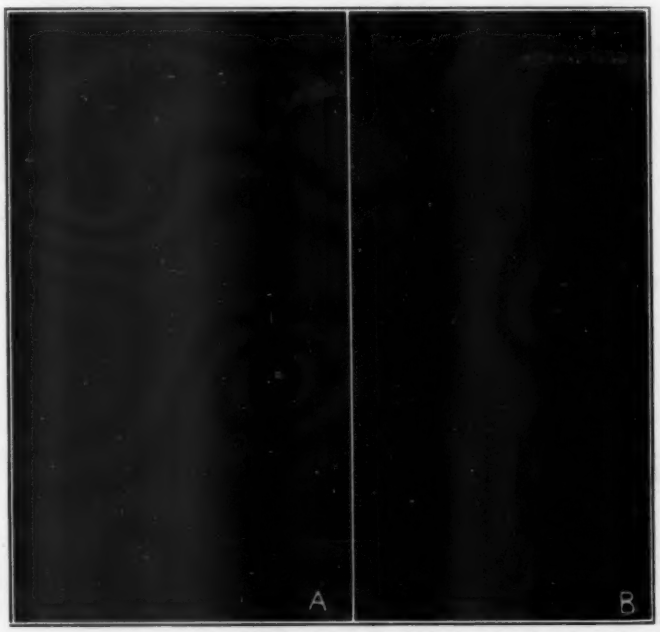

Fig. 9.—The influence of epinephrin on the fall in blood pressure produced by ether: *A*, before the administration of epinephrin; *B*, after the animal had been resuscitated with a large dose of epinephrin. In each case, the inhalation of ether was continued to the point where the eye reflex disappeared.

overetherized and had to be resuscitated with a large dose of epinephrin injected directly into the carotid artery. Following its recovery, the animal was very resistant to the effects of ether. The second record in the illustration was taken nearly two hours later. It shows the absence of blood pressure influence by the inhalation of ether under the same conditions as in the first record; i. e., in both cases, the animal was anesthetized until the eye reflex could no longer be elicited.

Evidence has already been presented indicating that the fall in blood pressure produced by ether is largely due to an influence on the heart.

The fact that epinephrin reduces this effect at once suggests that it also acts through the heart in an antagonistic manner. There are a number of observations which support this view. In the course of these experiments, animals were not infrequently overetherized to the extent that there was a complete cessation of the heart beat. While they are in this condition, a strong injection of epinephrin directly into the arteries is always effective in restoring the beat, even though at that time the heart is undoubtedly surrounded by fluid containing ether at a toxic concentration. Gottlieb [41] found that epinephrin exerted a beneficial effect in chloroform poisoning. In a series of experiments on the perfused isolated heart of rabbits and cats, Gunn [42] showed that epinephrin can antagonize a concentration of chloroform which alone markedly enfeebles the heart's contractions. In some recent experiments, Ransom [43] has shown that, in the isolated frog heart, depressed by chloroform, there may be complete restoration by the addition of small quantities of epinephrin to the chloroform solution.

Since there is no good evidence that the fall in blood pressure resulting from the administration of ether is caused by any effects on the peripheral vessels, it is unlikely that the protecting effect of epinephrin can be explained through its effect on the blood vessels. Pituitary extract, which is practically without influence on the heart, but which causes strong contraction of the smooth muscle of the arterioles, is absolutely without effect in influencing the blood pressure fall from ether. If this drop were due to an effect on the peripheral resistance, it should be less marked after the administration of pituitary extract.

THE EFFECT OF ETHER ON THE BLOOD VESSELS

Literature.—There is no agreement in the conclusions reached by different observers as to the influence of anesthetics on the vasomotor center, some reporting a dilatation of the blood vessels, and others a constriction under ether and chloroform. The direct consideration of the question is difficult, and many of the conclusions have been reached by inference from blood-pressure changes, etc.; which probably accounts for some of the discrepancies. Moreover, the reactions resulting from the administration of anesthetics are not uniform and may be dependent on a number of factors. Since the blood pressure effects of chloroform are so marked, much of the earlier work has centered around the action of this anesthetic. Brief mention of these papers will be included in the following short review of the literature on the action of ether on the blood vessels.

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41. Gottlieb: Arch. f. exper. Path. u. Pharmakol. **38**:99, 1897.
42. Gunn: Quart. J. Exper. Physiol. **7**:75, 1913.
43. Ransom, F.: J. Pharm. and Exper. Therap. **14**:367 (Jan.) 1920.

Among observers reporting a dilatation of the peripheral vessels from the influence of chloroform are Scheinesson,[44] from a study of the blood vessels in the rabbit ear, the dilatation being attributed to a direct action on the vessel walls; Knoll,[14] from direct observations on the rabbit ear; and Bowditch and Minot,[45] from blood pressure changes in the dog. In a series of papers, Embley [46] adduces evidence to show that, while the direct effect of chloroform on the vasomotor center is stimulative, the net effect on the kidney and intestines is dilatation, owing to a local action on the arterial wall. Later, Embley and Martin [47] published further experiments, confirming the results of their earlier work, in which they perfused the isolated organs through an artificial heart-lung preparation. Pick [17] studied the vascular action of various poisons by perfusion and plethysmographic methods, and found that the employment of both ether and chloroform resulted in a dilatation of the vessels of the brain and abdominal organs. Weber [48] by means of a plethysmograph, measured the arm volume of patients, following operation under chloroform and ether anesthesia, and found evidence of vasodilatation, lasting for several days. McWilliam [18] concludes from his experiments, in which the blood pressure and heart contractions were simultaneously registered, that, in the cat, ether inhalation causes a fall in blood pressure through its action on the blood vessels. Muns [49] made plethysmographic records on the hind leg of dogs under deep ether anesthesia; these showed volume changes which were attributed to a vasodilatation. Schram, Storm van Leeuwen, and van der Made [33] report experiments in which they obtained a drop in blood pressure by ether in a concentration which other experiments had shown to be without effect on the heart; they therefore conclude that the effect was due to an influence on the vasomotor center.

Opposed to the foregoing are the conclusions reached by a considerable number of workers. Among those finding evidence of a peripheral constriction from chloroform are Arloing,[50] from observations of the blood flow in the carotid, Diastra,[51] Roy and Sherrington,[52] and Hürthle,[53] from measurements of the changes in the brain volume; and

44. Scheinesson: Abst. Centralbl. f. d. med. Wissensch. **7**:506, 1869.
45. Bowditch and Minot: Boston M. & S. J. **90**:493, 1874.
46. Embley: Brit. M. J. **1**:817, 885, 951, 1902.
47. Embley and Martin: J. Physiol. **27**:147, 1905.
48. Weber: Med. Klin. **11**:991, 1915.
49. Muns, W. E.: Ann. Surg. **64**:645 (Dec.) 1916.
50. Arloing: Thèse, Paris, 1879.
51. Diastra: Les Anaesthetiques, 1890.
52. Roy and Sherrington: J. Physiol. **11**:97, 1890.
53. Hürthle: Arch. f. d. ges. Physiol. **44**:596, 1889.

Newman,[54] from direct observation of the pulmonary capillaries of the frog. Gaskell and Shore [55] carried out elaborate experiments to determine the place of action of chloroform in depressing the blood pressure. Two animals were arranged so that the brain of one was supplied by the blood of the other and was therefore isolated from its own heart. By these experiments, it was shown that, when blood from a chloroformed animal was allowed to circulate through the head of the second animal, it caused a marked rise in blood pressure, thus demonstrating a direct stimulation of the vasoconstrictor center by chloroform. At the same time, there was a fall of pressure in the first animal due to depression of the heart. These results were confirmed by the injection of chloroform directly into the carotid artery, which also resulted in a rise in blood pressure. Sherrington and Sowton [56] found that the amount of fluid passing through the coronary circulation of the isolated mammalian heart considerably diminishes when saline containing chloroform is substituted for the saline solution; from which they conclude that chloroform causes constriction of the arterioles. Schäfer and Scharlieb,[57] by determining the perfusion rate, using Locke's solution plus chloroform in various concentrations, found that, except in very dilute solutions, the arterioles were contracted by chloroform.

The effect of ether on the arterioles was investigated by Kemp,[58] from changes produced in the blood pressure and in the kidney volume. Ether gave an increase in the carotid pressure, along with a decrease in the volume of the kidney. Chloroform caused a fall in pressure and an increase in kidney volume. Düplay and Hallion [23] carried out a series of experiments on dogs to determine the causes of the variations in pressure produced by the inhalation of ether and chloroform. Along with observations on the heart and blood pressure, they made measurements of the kidney volume and reached the conclusion that the fall in pressure was due to an effect on the heart, and the rise to a stimulation of the vasomotor center. These anesthetics had a similar action; but with ether the heart depression was less and the stimulation of the vasomotor center much more intense. Likewise, the statement is made by Cushny [24] that the first effect is on the heart, which may result in an abrupt fall in pressure, but in other instances may be compensated for by vasoconstriction from reflex stimulation of the center, so that the blood pressure may rise while the heart is slowed. The experiments

54. Newman: J. Anat. & Physiol. **14**:495, 1879.

55. Gaskell and Shore: Brit. M. J. 1893, pp. 105, 164, 222.

56. Sherrington and Sowton: Report of the Chloroform Committee, London, 1903.

57. Schäfer and Scharlieb: Proceedings of the Physiological Society, J. Physiol. **29**:17, 1903; Tr. Roy. Soc., Edinburgh **51-52**:311, 1904.

58. Kemp: New York M. J. **70**:732, 765, 804, 1899.

of Muehlberg and Kramer [28] show that when ether or chloroform is injected into the carotid artery toward the brain, the blood pressure rises, presumably from a direct stimulation of the vasoconstrictor center. Airila [59] has attempted to determine the place of action on the circulation of ether and chloroform, through simultaneous measurements of the blood pressure and of the blood flow from the heart and in the peripheral vessels, by means of a stromuhr. It was found that the administration of either ether or chloroform resulted in vasoconstriction, except in very high concentration, in which case there was loss of vascular tone. At the same time, there was a depression of the heart, especially under chloroform anesthesia. Pilcher and Sollmann [60] have made a series of studies on the action of various drugs on the vasomotor center as inferred from the rate of perfusion of fluid through the vessels of the spleen and kidney. Ether was administered either through a tracheal cannula or by the injection of a saturated solution of ether in physiologic solution of sodium chlorid. The conclusion was reached that, given to the point of deep anesthesia, ether may stimulate the vasomotor center or be without action. When stimulation occurred, it was attributed to an indirect action secondary to a respiratory or circulatory depression. In a study of the capillaries of the cat ear, Hooker [61] has observed that, following death from ether, there is a marked constriction of the vessels, followed later by dilatation. This constriction, however, is attributed to the effect of asphyxia.

In the clinical literature, the statement is frequently made that ether causes a dilatation of the blood vessels. This general belief appears to be based on the observation that in the early stages of anesthesia there is an extensive flushing of the skin surfaces. The cause of the dilatation of the skin vessels is not evident; but it may be associated with a constriction of the arterioles of the internal organs and consequent increase in pressure. There is some evidence indicating that constriction occurs less readily in the superficial vessels. Dixon [62] has found, for alcohol, that there is a rapid dilatation of the skin vessels and at the same time a constriction of the vessels of the muscle tissue, and, to a less marked degree, of the splanchnic area. Moreover, as has been shown by Dastre and Morat,[63] in ordinary asphyxia, the blood vessels of the ear, face and extremities dilate, while those of the viscera contract, the increase in pressure resulting from a predominance of vasoconstriction in the visceral area over dilatation of the superficial vessels.

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59. Airila: Skand. Arch. Physiol. **40**:241, 1920.

60. Pilcher and Sollmann: J. Pharm. and Exper. Therap. **6**:401, 1915.

61. Hooker: Am. J. Physiol. **54**:30 (Nov.) 1920.

62. Dixon: J. Physiol. **35**:346, 1907.

63. Dastre and Morat: Recherches sur le systeme nerveux vasomotor, Paris, G. Neasson, 1884.

In an effort to throw further light on the causes of pressure variations occurring during the administration of ether, observations were made on the condition of arterial tone simultaneously with the taking of blood pressure records. This was done mainly by measurements of the leg volume by means of a plethysmograph, and by observations on the perfusion rate of fluids through the arteries of the legs. Further information is obtained by observation of the effects of the direct injection of ether solutions into the veins and arteries, and also by an examination of the blood pressure curves in conjunction with the effects on the heart.

Experiments on Leg Volume.—In the investigation of the effect of ether on the tone of the arterioles, a number of observations were made on the leg volume, as indicated by the plethysmograph. The very simple form of apparatus described by Dale and Richards [64] was employed. This consisted of a glass cylinder about 5 cm. in diameter, over one end of which was tied a rubber dam; a circular hole in this rubber permitted the insertion of the leg of the animal and made a tight joint, which was further sealed with petrolatum. The other end of the glass cylinder was connected through rubber tubing to a volume recorder. Changes in leg volume were transmitted by means of water, with which the whole system was filled. Simultaneous blood pressure and leg volume records were registered on the kymograph. With the exception of the addition of the plethysmograph and recorder, the general arrangement of apparatus was the same as that already described for obtaining blood pressure records, and the method of ether administration was exactly the same. The experiments were all performed on cats under ether anesthesia.

By this method, leg volume determinations were made on eight animals; of these determinations, two were unsuccessful on account of difficulties in technic, and the remaining five uniformly showed a decrease in leg volume as often as the ether was administered. The method is not well adapted for the determination of vascular changes produced by ether, on account of the accompanying fall in blood pressure and the resulting decrease in leg volume. Undoubtedly, this factor accounts for part of the volume change recorded; but an analysis of the tracings indicates that there is, in addition, an active vasoconstriction. Figure 10 shows records taken from Experiment 59 *c*. In the first tracing, the plethysmograph record shows a decrease in the leg volume along with the fall in arterial pressure; but this decrease is maintained during the recovery of the pressure while ether is still being administered, and, therefore, cannot be accounted for by a passive collapse of the blood vessels, but rather must be due to an active constric-

64. Dale and Richards: J. Physiol. **52**:110 (July) 1918.

tion. In another experiment, tracings from which are illustrated in Figure 11, an animal was used which gave practically no fall in blood pressure, but which, nevertheless, showed the usual decrease in leg volume. It is quite unusual to find an animal which shows so little change in the blood pressure from the inhalation of ether; but since such animals show the usual heart depression and the vasoconstrictor effects from ether, it seems probable that these two factors are so balanced that the blood pressure remains constant. The second tracing shows the disappearance of the effect on the leg volume after cutting the sciatic and crural nerves to the leg, indicating that the vasocon-

Fig. 10.—The effect of ether on the leg volume of an animal: *A*, before shock; *B*, during shock. Top record, blood pressure with mercury manometer; middle record, leg volume, a rise indicating a decrease in volume; lower record, zero blood pressure, with signal marks to indicate the duration of ether inhalation.

striction results from a central influence rather than from a direct effect on the walls of the blood vessels. After these records were obtained, the plethysmograph was shifted to the opposite leg and the procedure repeated with exactly the same result, ether no longer causing a reduction in the leg volume after the nerve supply was cut.

From these experiments, it may be concluded that the administration of ether, as in ordinary anesthesia, results in a constriction of the peripheral vessels, which is mediated through the vasomotor nerves. How much of this effect is due to reflex stimulation of the center through

the lowered blood pressure, and how much to a direct stimulation of the center by ether, remains a question. Experiments to be described later indicate that both factors may enter into the result. That ether has no important direct vasoconstrictor action in the concentration present in the blood during surgical anesthesia in the normal animal is indicated by the leg volume experiments described above. If any part of this vasoconstriction was due to a direct action on the walls of the blood vessels, the effect should persist after nerve section. The fact that there is no dilatation in these experiments cannot be taken as proof that ether does not have a direct vasodilator effect, for these

Fig. 11.—The effect of ether on the leg volume: *A*, in intact animal; *B*, after cutting all the nerves to the leg. Upper record, blood pressure with mercury manometer; middle record, leg volume, a rise in the curve indicating a decrease in leg volume; lower record, zero blood pressure, showing periods of ether inhalation.

observations were made within a short period after cutting the nerves. As has been pointed out by Dale and Richards,[64] it is important to take into consideration the almost maximum vasodilatation which occurs in the vessels of the leg immediately after its nerves are cut, any further dilatation being impossible.

The demonstration, by the plethysmograph and by perfusion experiments described below, that there is actually vasoconstriction in the

hind legs under ether anesthesia in the intact animal shows, however, that if there is any direct relaxing effect on the walls of the blood vessels, it is very slight and not sufficient to overcome the constrictor effect produced by the increased tone of the vasomotor center. Even under deep anesthesia, the vasomotor reflexes, as demonstrated by the asphyxial rise in blood pressure, are still functioning

Experiments on Perfusion Rate.—In an attempt to obtain further evidence on the condition of arterial tone in ether anesthesia, perfusion experiments were carried out. The method used was a modification of that described by Bartlett.[65] The perfusion fluid was injected through a buret, which was connected directly with the artery by means of a wash-out cannula. A side tube on the buret, connected with a bottle of Ringer's solution, served to refill the buret to the original level after each injection. The liquid in the buret was subjected to a constant pressure of 120 mm. of mercury, which was obtained by means of a rubber atomizer bulb connected through a 4 liter bottle. This bottle, which served as a pressure tank, was sufficiently large, so that the loss of a few cubic centimeters of fluid from the buret during the perfusion resulted in no appreciable change in pressure. These experiments were all performed on cats, decerebrated or under light ether anesthesia. Perfusion was always done through the femoral artery. The inflow cannula was placed in a side branch of the artery, or, which amounted to the same thing, low down on the main branch directed toward the heart. When a determination of the rate of inflow was to be made, a clip was momentarily placed high up on the main trunk, so that all the fluid had to pass through the capillary bed of the leg. A second clip, immediately in front of the cannula, was then removed, which allowed the perfusion fluid, usually from 2 to 3 c.c., to pass into the vessels, the time being recorded with a stop watch. Immediately after the observation the upper clip was removed, thus allowing the part to receive its natural blood supply. Ether was administered by inhalation in the usual manner.

Before the ether was given, a number of determinations of perfusion rate were made in order to obtain the normal rate for the particular preparation. Ether was then given and the observations were continued, usually at intervals of about one minute as the animal became more deeply anesthetized. If etherization was pushed to an extreme, so that the second fall in pressure occurred, there was a sudden increase in perfusion rate, which was greater than that at the start. The constriction resulting from ether is well marked; for example, in one experiment on a decerebrated cat, the average perfusion time was three and one-tenth seconds for each cubic centimeter of fluid. This increased to ten and one-tenth seconds during the development of anesthesia, and gradu-

65. Bartlett: J. Exper. M. **15**:414, 1912.

ally dropped back to the original rate after the ether was removed. A number of representative charts taken from these experiments are shown in Figures 12, 13 and 14. The fifth experiment was negative as far as any effect of ether on the perfusion rate was concerned, although the vasomotor center was active, as indicated by the rise in blood pressure resulting from asphyxia. Too much reliance, however, should

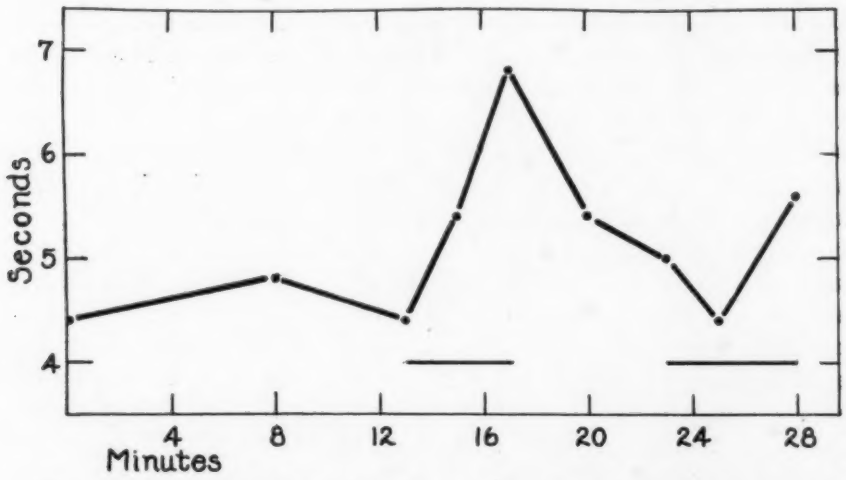

Fig. 12.—The effect of the inhalation of ether on the perfusion time of a fluid through the vessels in the hind leg of a cat. The horizontal line below the graph shows the period during which ether was administered.

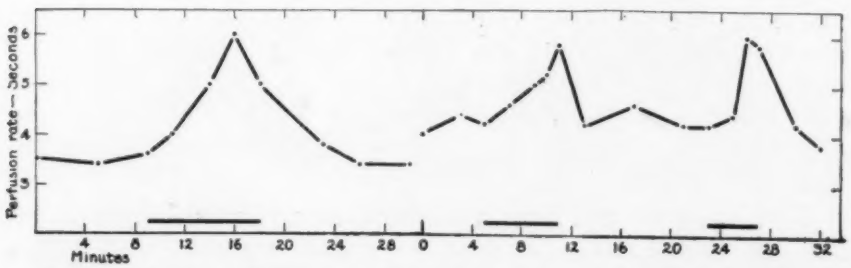

Fig. 13.—Same as Figure 12; the effect of ether on the perfusion time in two other animals.

not be placed on negative results, as the method involves considerable possibility of injuring the nerve supply to the leg through disturbance of the circulation. On the other hand, a decrease in perfusion rate during the administration of ether gives positive evidence of vasoconstriction. Two other animals failed to show any evidence of constriction under ether (Fig. 17); but they also failed to show the usual recovery in blood pressure after the primary fall, and did not show an asphyxial

rise in blood pressure, thus giving the type of reaction found in shock. These experiments will be referred to later, in considering the condition of the vasomotor center in shock. The last two experiments of the series both showed a characteristic and well-marked constriction.

The Effect of Ether Introduced Directly into the Circulation.—If the effect of ether on the heart is one of depression, and the effect on the vasomotor center one of stimulation, it should be possible to get

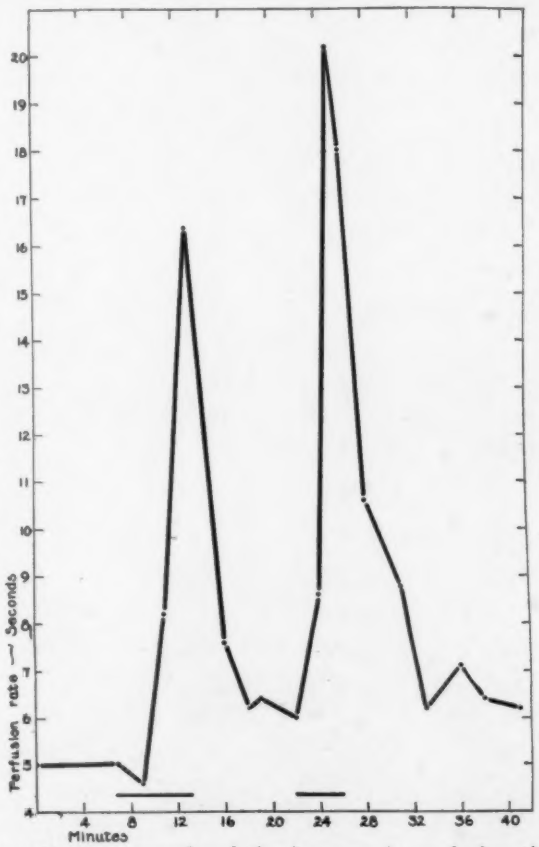

Fig. 14.—An extreme example of the increase in perfusion time during the administration of ether. The horizontal lines below the graph show the period during which ether was inhaled.

different effects on the blood pressure, depending on whether ether is injected into a vein, or into an artery toward the head. As previously mentioned, such methods have been used by other workers to obtain evidence on the place of action of anesthetics. In the course of the present investigation, a number of such observations have been made; the injections of ether toward the heart being made through a cannula in the femoral vein, and those toward the vasomotor center through

a cannula in the carotid artery. The most convenient method for introducing the ether was by means of a saturated solution in physiologic solution of sodium chlorid (approximately an 8 per cent. solution at room temperature), which could be diluted to any desired strength.

The results from such injections show a definite and uniform difference. Figure 15 presents two examples of the different effects obtained

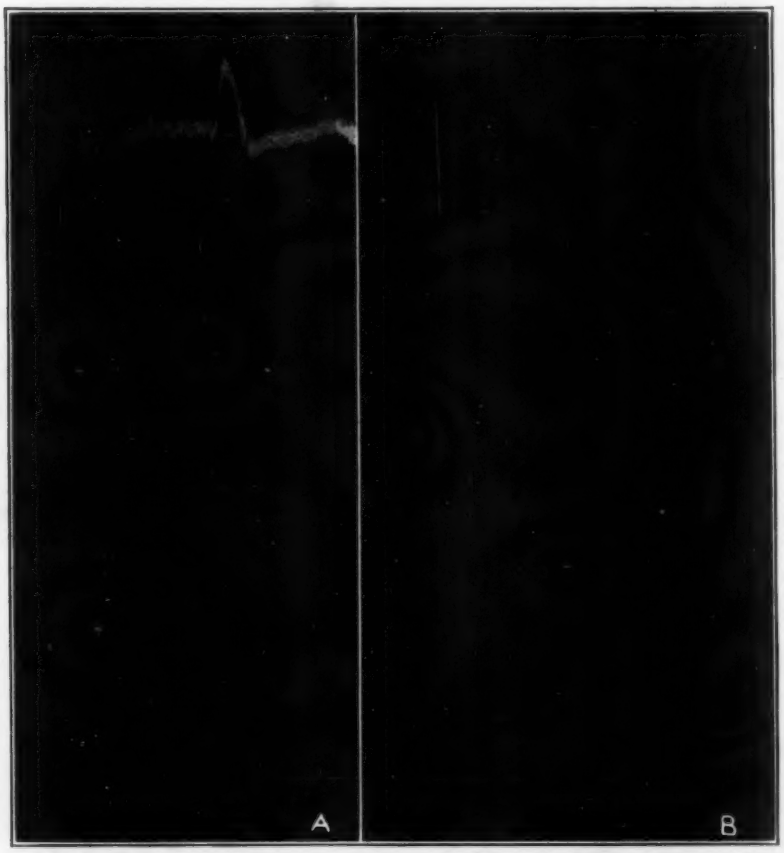

Fig. 15.—Records from two animals, for a comparison of the effect of injecting ether into the veins and into the arteries. In both records, the first pressure change is due to the injection of 0.5 c.c. of a saturated solution of ether in physiologic solution of sodium chlorid into the femoral vein toward the heart; while the second pressure change is due to a similar injection into the carotid artery toward the head.

from the arterial and from the venous injection of ether, taken from two different animals. In each case, the first injection was made through the femoral vein, and the second into the carotid artery toward the brain. The effect of the arterial injection of the ether solution is an immediate

rise in blood pressure, which in some cases is quite prolonged. Later, there may be a temporary fall below the original level, which is presumably caused by an effect on the heart. This is shown in the second record of Figure 15. Physiologic solution of sodium chlorid containing no ether is absolutely without effect in such small amounts; but even with very dilute ether solutions, comparable to the concentrations found in the blood of anesthetized animals, there may be a considerable stimulation of the center, as indicated by the rise in blood pressure. Exactly

Fig. 16.—The effect of a first injection of 1 c.c. of a saturated solution of ether in physiologic solution of sodium chlorid into the femoral vein of a cat. Top record, blood pressure with mercury manometer; bottom record, zero blood pressure.

the opposite effect is obtained from the injection of the ether solutions into the femoral vein. Here the heart is reached first, and the effect is a definite though transitory drop in blood pressure. This may be followed by a gradual rise in pressure considerably above the original level, sometimes lasting for ten minutes or more. The first ether injection in a freshly prepared animal practically always induces such a rise following the primary fall (in twelve out of thirteen animals), but

later this does not occur. A tracing illustrating a typical example of this effect is shown in Figure 16. Since the injection of ether directly toward the brain causes a rise in blood pressure, it seems probable that this increase in pressure following the primary drop is also due to an influence of ether on the vasoconstrictor center.

Deductions from Blood Pressure Changes.—The form of the blood pressure curve resulting from the administration of ether in the normal animal at once suggests that part of the effect is due to an influence on the vasomotor center. A typical record, as given in Figure 1, shows, after the primary drop, a recovery of the blood pressure, which takes place while the anesthetization of the animal is becoming deeper. Evidence has already been given that during this time there is a continuous weakening of the heart action, which would tend progressively to lower the blood pressure. If this is true, the only assumption that will account for the recovery of the blood pressure during the inhalation of ether is an increased peripheral constriction. This, moreover, is a logical consequence of the drop in pressure resulting from a lessened heart output, quite apart from any direct stimulation of the vasomotor center. That the normal vasomotor reflexes are present even in deep anesthesia has been shown by Bowditch and Minot [45] and by Scheinesson.[44] While no special experiments have been made on the subject, it has been repeatedly observed in the course of this research that animals under deep anesthesia exhibit the usual vasomotor responses. This is further supported by the results of ether administration in shock, when it is found that in animals which do not exhibit vasomotor reactions there is also an absence of recovery of blood pressure.

The Effect of Ether on the Peripheral Tone in the Shocked Animal.—The changes occurring from the effect of ether on the blood vessels and vasomotor system in shock can be discussed to better advantage after a consideration of the causes leading up to these changes. Here it will be sufficient to record only the experimental data obtained from the administration of ether in shock. It may be stated, however, that all the evidence indicates that the changes observed are referable to an abnormal condition of the vasomotor center; either an already existing maximum constriction of the blood vessels or a depression of the center.

The change which occurs in the blood pressure curve from the administration of ether in the shocked or "sensitive" animal has already been described. It is illustrated in the tracings shown in Figure 2. The fact that the primary fall is no longer followed by recovery suggests that the normal functioning of the vasomotor center has been impaired and that there is no compensation for the decreased activity of the heart, the pressure continuing to fall as the anesthesia deepens.

The extreme alterations in pressure produced by ether make the measurement of vascular changes very difficult. Plethysmograph records are unsatisfactory on account of the shrinking of leg volume resulting from the decreased pressure, making it practically impossible to judge whether constriction still occurs. In only one out of a number of experiments was it possible to get evidence on this point. Records from this case are shown in Figure 10. The first tracing shows the blood pressure and leg volume changes resulting from the administration of ether at the beginning of the experiment, and the second tracing, obtained under exactly similar conditions, shows the change produced after the development of shock. Here, after the animal has become sensitive to the ether, there is no indication of constriction; indeed,

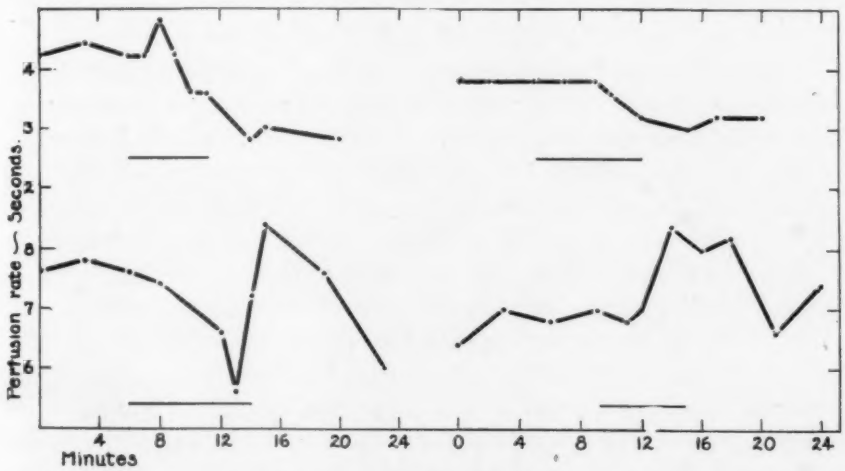

Fig. 17.—The absence of an effect, from ether, on the perfusion time in animals in a condition of shock. The horizontal lines below the graphs show the period during which ether was administered. Compare with Figures 12, 13 and 14.

there is probably some dilatation, since there is no decrease in leg volume associated with the very considerable drop in arterial pressure. A number of observations on this cat gave similar results.

Evidence obtained from perfusion of the hind legs in shocked animals has already been given. In these experiments, three cats gave no indication of a vasoconstriction during the administration of ether. Two of these animals showed a definite sensitivity to ether, and failed to show any rise in blood pressure under asphyxia. Charts from these experiments are shown in Figure 17. Negative results of this nature must be accepted with caution. They are, nevertheless, recorded here as a further indication of the difference between the normal and the shocked animal.

There is a close comparison between the extent of the drop caused in the blood pressure curve by ether and the rise in blood pressure brought about by asphyxia: the animals giving the greatest pressor response to asphyxia show the greatest resistance to ether. In an animal going into shock, these reciprocal changes occur simultaneously. Similarly, the rise in pressure caused by ether injected directly toward the brain is greater in the normal animal. It is from such observations as these that the main evidence must be obtained regarding the condition of the vasomotor center in the animal sensitive to ether. They will be discussed in greater detail after a consideration of the causes leading up to this ether "sensitiveness."

THE CAUSE AND DEVELOPMENT OF THE INCREASED SENSITIVENESS TO ETHER IN SHOCK

An examination of the different ways of inducing in an animal the condition in which ether so markedly affects the blood pressure throws further light on the probable cause of the condition. It is always associated with shock, and is gradually developed under any circumstances that depress the general bodily condition of the animal, especially low blood pressure. Severe operation, hemorrhage, the injection of acid into the circulation, all cause a marked increase in the ether effect; and these various agencies depress the circulation, appearing to do so by an effect on the vasomotor center or peripheral mechanism rather than on the heart. Experimental evidence has already been presented which indicates that the fall in blood pressure resulting from ether is brought about through an effect on the heart, and that this is normally compensated for, to a considerable extent, by a peripheral constriction mediated through the vasomotor system. In shock, this mechanism appears to be no longer functioning, with the result that ether causes a continuous drop in pressure as the depth of anesthesia is increased. The question arises as to what change has occurred in the circulatory control which in the normal animal prevents the drop in blood pressure. Two possible explanations suggest themselves: There is some evidence that the low blood pressure accompanying shock results in a depression of the vasomotor center so that it no longer reacts in the normal manner to a fall in pressure or other stimulus. Secondly, there is the possibility that in this condition of ether sensitivity there already exists a maximum contraction of the arterioles, so that there is no possibility of a further increase in the peripheral resistance to compensate for the lessened output of the heart.

Production of Ether Sensitiveness by a Reduced Blood Pressure.—One of the simplest methods of producing shock and the associated ether sensitiveness is to interfere with the circulation so as to produce

a low blood pressure for a period of an hour or more. In these experiments, the routine method of bringing about the increased ether effect was that described in an earlier paper of this series,[13] in which there was an arrangement for increasing the intrapericardial pressure and thus preventing the normal return of the blood to the heart. Under artificial respiration, the thorax is entered between the ribs on one side at the level of the sternum, a small slit is cut in the pericardium and a glass cannula is tied in place. The thorax is now closed and the animal is allowed to breathe naturally. A small reservoir is connected with the cannula by means of rubber tubing and filled with physiologic solution of sodium chlorid or with 6 per cent. gum acacia in this solution. By raising or lowering the reservoir, the heart can be subjected to varying pressures, and any desired arterial level can be produced and maintained. In a few experiments, the arterial pressure was regulated by compression of the heart by a clamp applied to the chest. This method gives similar results, but is inferior in that it interferes somewhat with the respiratory movements.

The reduction of the blood pressure by these means to 60 mm. of mercury for one hour is practically always sufficient to cause a marked increase in the effects of ether on the pressure. In a very few cases, there was no such result, the reaction remaining much as it was before the pressure was reduced. Successive hours of this treatment served to increase still further the drop in pressure caused by ether. An example, taken from one of the earliest experiments carried out at Dijon, is shown in Figure 18. In this case, ether was administered by simply connecting the ether bottle with the tracheal cannula in a cat and allowing the animal to breathe through it until the eye reflex could no longer be elicited. Before a test for the effect of ether was made, all pressure was removed from the heart and the blood pressure was allowed to rise. Recovery was not usually complete, but depended on the length of time the pressure had been reduced.

Production of Ether Sensitiveness by the Injection of Acid into the Circulation.—There are a few observations indicating that the simple injection of acid into the circulation will produce in an animal a condition in which the administration of ether results in a fall of blood pressure. In the course of a study made by the members of the Medical Research Committee of England to determine the influence of acidosis in the production of shock, it was noted that, after the injection of acid into the circulation of cats, they became exceedingly susceptible to the influence of anesthetics.[25] A few incidental observations made in the course of the present research confirm the findings of the British committee. That such treatment should affect the normal action of the

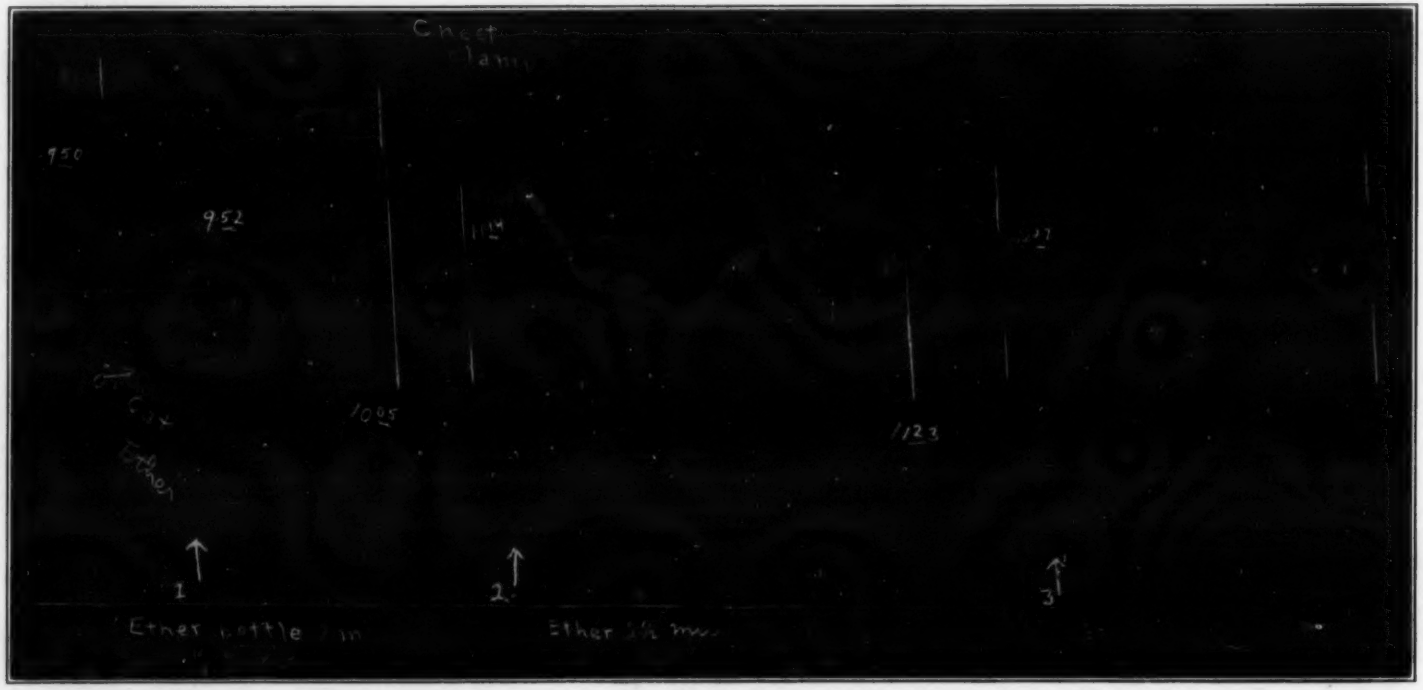

Fig. 18.—The development of ether sensitiveness from low blood pressure. Arrows mark the beginning of ether inhalation, which in each case was continued until the eye reflex just disappeared: 1, before reducing the blood pressure to 60 mm. of mercury; 2, after one hour of low pressure; 3, after two hours of low pressure.

vasomotor center is not surprising. The increased hydrogen ion concentration would strongly stimulate the medullary centers,[66] causing a constriction of the peripheral vessels. Under these circumstances, it is to be expected that the delicate mechanism by which the vasomotor center normally responds to a fall in pressure would no longer be operative. There would thus exist a condition which, through the action of ether on the heart, would result in the continued fall in blood pressure.

Fig. 19.—1, the effect of ether before hemorrhage; 2, after hemorrhage. In the first record, the administration of ether was continued for two minutes, while in the second record it was administered for only one minute.

Production of Ether Sensitiveness by Hemorrhage.—Another method by which increased sensitiveness to ether may be produced is bleeding. In a typical case, if the animal is bled from 15 to 20 per cent. of its total blood volume, there will be a recovery from the resulting drop of blood pressure within a few moments. Ether administered at this time will produce a marked drop in blood pressure, similar to that produced in shock; while before the bleeding no such drop resulted, or

66. Mathesson: J. Physiol. **42**:283, 1911.

only a transitory one. Such an effect is shown in Figure 19. Under these circumstances, there must already be present at the time of the administration of ether, as shown by the recovery of the blood pressure following the hemorrhage, a strong peripheral constriction; and it is clear that, in this condition, there is less opportunity for a further reflex constriction to compensate for the reduced cardiac output; consequently, the ether effect shows itself in a greatly increased fall of arterial pressure.

Results such as these are the rule, but occasionally animals are encountered which show absolutely no increased sensitiveness to ether

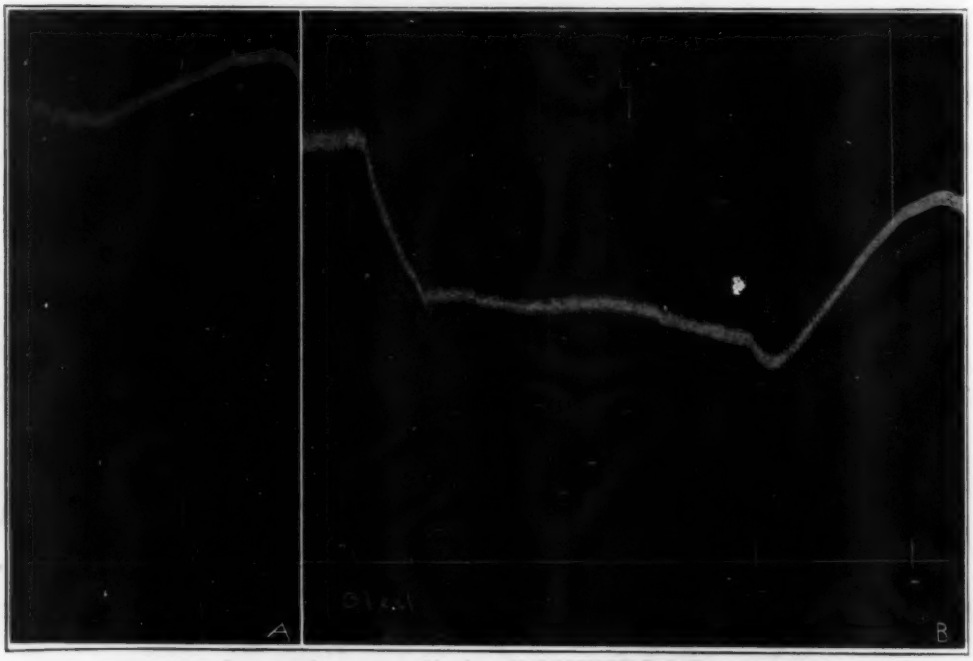

Fig. 20.—The effect of hemorrhage on the ether effect in an animal in which the pressure remained low after the removal of 22 c.c. of blood (weight of cat, 3.25 kg.). Signal marks on base line (zero blood pressure) show duration of ether inhalation, which was for two and one-half minutes in each case.

after even a severe hemorrhage. In Figure 20, a tracing is shown from an experiment in which ether caused an actual increase of pressure when administered after bleeding. Two other animals gave results similar to the one shown in the illustration. In these animals, there was no reaction to the hemorrhage; that is, the pressure remained at the reduced level, perhaps indicating that there was no vasoconstriction. This gives a clue to a possible explanation. It is conceivable that, although the center did not respond naturally to the reduced pressure,

the ether in the blood was able to stimulate the center directly and that this caused a peripheral constriction, which, at this low level of blood pressure, was more than sufficient to compensate for the effect on the heart, with the result that the blood pressure was increased.

Production of Ether Sensitiveness by Other Causes.—As stated previously, there may be a gradual increase of the ether effect in animals which have not been specially treated to produce shock. This occurs after severe operations, such as decerebration and chest operations, and after long experimental procedures in which the animal has been kept under an anesthetic for several hours. It seems that any circumstances which tend to depress the general bodily condition of the animal cause, at the same time, this changed reaction toward ether. Undoubtedly, such conditions cause a certain amount of circulatory derangement in the direction of shock, and the vasomotor reactions become impaired. In general, a very close inverse relation exists between the rise in blood pressure resulting from asphyxia and the fall occurring from ether, the greater effect of ether being associated with a depression of the vasomotor reactions. This is true no matter by what method shock is produced, and, in animals which show absolutely no asphyxial rise, the effects of ether are always extreme. Occasionally, animals are found which exhibit a sensitiveness to ether from the very beginning of the experiment; but almost invariably such animals are in poor condition and have a low blood pressure.

COMMENT

The evidence presented in the preceding pages supports the supposition that the drop in pressure produced in the shocked animal is due to some disturbance of the vasomotor system. Since the causes of shock are not well understood and there is no agreement among the physiologists regarding the condition of the medullary centers in this condition, it is not possible to define, with any degree of certainty, the cause of the changed reaction to ether occurring during the development of shock. Determinations of the alkaline reserve made in this laboratory [13] indicate that the reduction of the blood pressure below 70 mm. of mercury by means of intrapericardial pressure is sufficient to result in an inadequate oxygen supply to the tissues; and it is probable that this is followed by a depression of the nerve centers. That this is true for the vasomotor system is indicated by the fact that the longer the pressure is kept at such a low level, the less pronounced the recovery will be after removal of the pressure on the heart. Moreover, animals which have been treated in this way show no or very little response to asphyxia. But this cannot be the whole explanation. The forced reduction of the blood pressure would undoubtedly call forth a reflex or asphyxial stimulation of the peripheral vessels which would probably

be maximum. Indeed, it has been shown by Erlanger, Gesell and Gasser,[67] in perfusion experiments, that there is such a constriction in the similar condition brought about by occlusion of the vena cava. Both factors might be of importance; a depression of the vasomotor center possibly resulting from the continued stimulation and from oxygen deficiency, while at the same time the tone of the center would be maximum for its condition at any moment. With prolonged low pressure, the center would finally become unresponsive and the original constriction would give way to dilatation. This, in fact, was the case in Erlanger's experiments with occluded aorta, and in experiments carried out in this laboratory with muscle injury shock.[68]

This increase of the effect of ether in shock does not apply to ether injected directly into the circulation in small amounts, but is true only for the inhalation experiments, when a general anesthesia is produced. Numerous observations have failed to show any considerable increase of the drop in arterial pressure brought about by the injection of small amounts of ether dissolved in physiologic solution of sodium chlorid, even when the animal has become markedly sensitive to the effects of inhaled ether. In the light of the experiments showing that the drop is due to an effect on the heart, and in consideration of the very small transitory effect produced by such small injections, this result is to be expected. When the ether is injected into a vein, it reaches the heart in a relatively high concentration, which is sufficient to cause a drop in pressure; but this effect does not last more than a few seconds and there is an almost immediate recovery, without the possibility of bringing a compensatory vasoconstriction into action. If the blood pressure curve from injected ether in the normal animal is not modified by vasomotor influences, there is no reason why the ether effect should be modified by any change in the vasomotor center or peripheral vessels occurring in shock.

In a series of experiments [68] on the perfusion rate of fluid through the vessels of the hind leg of the cat during the development of muscle injury shock, it was found that, as the blood pressure fell, there was a gradually increasing constriction of the peripheral vessels; and there are in the literature many observations indicating that the centers, at least during the early stages of shock, are not depressed.[38] On this basis, it must be assumed that the increased effect of ether in shock is a consequence of the strong vascular contraction which exists in this condition, preventing the normal compensation for the depression of the heart, rather than of a similar condition showing itself from a paralysis

67. Erlanger, I.; Gesell, R., and Gasser, H. S.: Am. J. Physiol. **49**:90 (June) 1919.

68. Cattell: Science, **55**:434, 1922.

of the center. A depression of the center, however, probably ultimately results as a secondary effect of the prolonged low blood pressure. Thus, either of these two changes in the condition of the center may play a part in the result. But in the present consideration of the cause of the changed effects of ether in shock it is perhaps better, with such evidence as we have at hand, not to attempt to define too closely the exact change which has occurred in the center. All the evidence indicates that there is some disturbance of the delicately balanced arrangement for the control of the vascular tone. Whether stimulation or depression of the center is concerned in this change, the effect is one which destroys the normal reactions to a decreased pressure.

There is another factor which may be a contributory cause in the fall in blood pressure resulting from the administration of ether in the shocked animal. The literature on the direct action of ether on the blood vessels gives no conclusive evidence that there is or that there is not an effect on peripheral tone. If ether causes relaxation of the musculature of the blood vessels, as might be expected from its depressive action on heart muscle, etc., it certainly does not show itself in the intact animal. But if, in the condition of shock, there is a depression of the vasomotor center, it is conceivable that such a direct dilating action might make itself felt, and thus contribute toward the fall in pressure.

In discussing the effects of ether in shock, it has been assumed that the depressive action of this substance on the heart is sufficient to account for the fall in pressure; but no evidence has been adduced to indicate whether or not there is a direct depressant action on the vasomotor center in this condition. In the normal animal, all the evidence indicates that there is no depressive action on any part of the vasomotor system or blood vessels. The rise in blood pressure associated with a depression of the heart shows that there is stimulation of these parts of the circulatory system. The removal of this compensatory factor for the decreased heart output in shock seems sufficient to account for the greater fall in pressure resulting from ether anesthesia in this condition. Nevertheless, it is not inconceivable that, while in the normal animal ether results in a reflex stimulation of the center, in the shocked animal and after hemorrhage, when the center is already in a condition of maximum tone, it results in a gradual depression of the center, from its narcotic action.

SUMMARY AND CONCLUSIONS

1. In the normal animal, the inhalation of strong ether results in a sudden drop in the arterial pressure, which is quite temporary. As the anesthesia deepens, the pressure gradually recovers until, by the time the eye reflex has disappeared, it may have returned to its original level.

2. In the shocked animal, there is no recovery of the blood pressure after the primary fall, and the pressure continues to fall to zero even before the eye reflex disappears.

3. Nitrous oxid and oxygen, in the most favorable proportions, can be administered to the shocked animal without causing more than a slight drop in blood pressure.

4. Observations on the heart volume of intact cats, and on the contractions of the isolated cold-blooded heart, together with deductions from blood pressure records, show that the administration of ether, from its very beginning, results in a depression of the heart and a decrease in its output, which is sufficient to account for the fall in pressure in both the normal and the shocked animals.

5. The injection of large doses of epinephrin intravenously in shocked animals usually results in the disappearance of the sensitiveness to ether for a period of an hour or more. Evidence is cited indicating that this is due to an antagonistic action of the ether on the heart. Pituitary extract does not influence the pressure drop produced by ether in the shocked animal.

6. Determinations of leg volume with a plethysmograph, perfusion rate measurements, and results obtained by the injection of ether directly into the circulation, together with the form of the blood pressure curves, indicate that ether causes a contraction of the peripheral vessels. This constriction may be caused by (*a*) a direct stimulation of the vasomotor center and (*b*) a reflex to the fall in pressure resulting from a depression of the heart.

7. In the blood pressure curves resulting from the administration of ether in the normal animal, the primary drop is probably due to an influence on the heart; and the subsequent recovery of the blood pressure, to a compensatory vasoconstriction.

8. In the shocked animal, no evidence of a vasoconstriction produced by ether was obtained, and pressor effects from asphyxia or sensory nerve stimulation become less or are entirely absent.

9. The condition of ether sensitiveness is brought about by any circumstances which tend to depress the general condition of the animal, such as low blood pressure, hemorrhage, severe operations or the injection of acid into the circulation.

10. The cause of the greater depressing influence of ether on the blood pressure in shock appears to be due to a disturbance of the vasomotor system. The usual compensatory constriction no longer occurs to offset the decreased output of the heart, and the pressure continues to fall. This might be due to a depression of the vasomotor center or to an already existing maximum tone of the center so that there could be no compensation.

THE ROENTGENOLOGIC ASPECT OF CHRONIC APPENDICITIS

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Much has been written during the last ten years on the roentgen-ray examination of the appendix. The views expressed by the various writers in this time, excluding a certain amount of overenthusiasm, have differed only in minor details and in the exact dependence to be placed on some of the observations made concerning pathologic conditions of this structure and of the surrounding organs. The value of the roentgenologic examination in connection with appendicitis may be discussed under the following heads: (1) congenital anomalies in position; (2) data obtainable from observation of the visualized appendix; (3) abnormal appearances in other structures suggesting appendiceal origin when the appendix is not visualized; (4) the finding of some other condition than appendicitis to account for the symptomatology; (5) the finding of some other condition accompanying appendicitis and requiring further surgical exploration, and the exclusion of any other surgical condition than a diseased appendix, thereby avoiding further exploration.

VALUE OF ROENTGENOLOGIC EXAMINATION IN CONNECTION WITH APPENDICITIS

Practically all that can be said on this subject is a consideration of the possibilities of detecting a chronically diseased appendix or the results of previous inflammatory disease by means of a roentgen-ray examination. In only rare instances is it necessary or wise to submit a case of acute appendicitis to a roentgenologic gastro-intestinal study, and certainly never is it necessary when a correct diagnosis has been made.

1. The only congenital anomalies which need consideration are transposition of viscera, in which case the cecum and the appendix, if visualized, will be found on the left side; and failure of complete rotation of the cecum, when the demonstration of the anomalous positions of the bowel may be of help in diagnosis and of assistance to the surgeon at operation.

2. Much valuable data may be obtained when the appendix is visualized. Unfortunately, this does not occur in every instance in which a gastro-intestinal study is made. The exact proportion varies

considerably with different observers. Visualization depends on the patency of the lumen to the barium or bismuth taken with the opaque meal. It seldom occurs during an opaque enema. At first, visualization was regarded as evidence of disease, but this view was soon discarded. Conversely, the lack of filling of the appendix has been regarded as the result of obliteration of the lumen through disease. Naturally such obliteration prevents filling; but it is not to be expected that every normal appendix will fill with contents of the cecum at all times. Our dependence on observation of the visualized appendix lumen must be limited to a certain proportion of cases. The study of the visualized structure must be mainly fluoroscopic, although plates must be made; but when they are, it must be done under fluoroscopic control, as the shadow is so frequently hidden by other portions of the barium filled bowel. The diagnosis of disease is based on many appearances. Adhesions to the cecum, pelvic colon, ileum or other structures must be determined from fixation detected by the use of the palpating spoon. A kink that cannot be straightened or that tends to recur after straightening is good evidence of adhesions. A sharp kink may prevent filling of the entire lumen. The length and position and the caliber of the lumen are readily determined when the structure is visualized throughout. The relation between disease and irregular filling is one concerning which there is still some dispute. To ascribe the appearance invariably to constrictions arising from inflammatory thickening or cicatricial contractions cannot be exact, although it may be a correct interpretation in many instances.

The emptying time of a visualized appendix is an important observation. If the opaque contents remain after they have left the cecum, poor drainage is a correct inference. This in itself cannot be regarded as evidence of disease except so far as a poorly draining appendix can be regarded as a diseased appendix, or potentially so.

One of the most important observations to be made is the relation of the visualized appendix to pain on pressure. Naturally, more or less discomfort is usually experienced when firm pressure is exerted over the appendix or cecum; but when exquisite tenderness is experienced when the pressure is exerted directly over the appendix, especially when the pain is constant when the structure is moved from place to place, and there is little discomfort from firm palpation elsewhere in the immediate neighborhood, this finding is of considerable value, and must be of greater accuracy than a similar clinical finding when the exact location of a structure which is variable is unknown. Even if the appendix is not visualized, the roentgen ray always reveals its probable relation to the tip of the cecum, and tenderness at this point is always suggestive. One must be careful not to mistake tenderness due to a diseased appendix for that due to pressure on a ptosed kidney,

or over an inflamed tube or ovary in the case of a low lying cecum. In fact, it is wise to have clinical data furnished by a pelvic examination before interpreting tenderness over an appendix, in the case of a low cecum, as possible evidence of appendicitis. Patients are frequently found with extreme hyperesthesia of the skin, whereas if deep pressure is exerted when they are off their guard, the hyperesthesia may be differentiated from appendiceal tenderness.

A retrocecal appendix may be found by pushing out of the way a more or less movable cecum; but when the appendix is adherent or the cecum fixed, it may not be seen until the cecum is empty, or nearly so, of opaque contents. Whenever a retrocecal appendix is suspected because of its absence elsewhere and the evidence of adhesions or continued tenderness over the cecum, it is wise to continue the examination until the latter is empty. The finding of a retrocecal appendix is always an important one; but its significance in connection with the clinical aspect of the case must be carefully considered with the clinician and surgeon. Certainly, if it is long, fixed and pointing upward in a case with symptoms referable to the right upper quadrant, the value of such an observation may be very great.

The presence of fecal concretions or opaque foreign bodies, such as pins, in the appendix is obviously an important finding. It is probable that a small inspissated fecal mass will not show unless it becomes barium covered by the opaque meal, or calcium covered through the inflammatory process present or induced by the foreign body. It is, of course, most important that the shadow of a fecal concretion be accurately differentiated from a ureteral stone.

3. When the appendix is not visualized, the presence of disease must be indirectly inferred from abnormal appearances observed in connection with other structures, and it is quite possible for the organ to be diseased without any manifestations elsewhere. The most important finding is the presence of adhesions, especially in connection with the terminal ileum. If this structure is kinked or adherent to the cecum, the origin of such adhesions, in the absence of pelvic inflammatory disease, is probably the appendix. Occasionally, the pelvic colon will be found adherent to the cecum or drawn over to the right iliac fossa and fixed there. Ileac stasis alone, or contents in the terminal ileum eighteen hours or longer after ingestion of the meal, provided the gastric motility is not delayed, may be an evidence of a diseased appendix; but it cannot be safely regarded as a diagnostic sign, and is not very reliable. Continued exquisite tenderness at the tip or lower inner border of the cecum when the appendix is not visualized is a sign of considerable importance; but, of course, it does not possess the same value as the visible relation between the visualized structure and the tender point.

Definite pyloric spasm is an evidence of appendiceal trouble that should not be overlooked. It is by no means always present; but when observed, and not of such intensity as to suggest an intragastric cause, the right iliac fossa should receive a most careful examination. A cause may, of course, be found higher up, such as a diseased gallbladder or gallstones, which may sometimes produce pyloric spasm.

4. That there are many conditions the symptoms of which may more closely simulate those of chronic appendicitis is shown by the frequency with which the roentgenologist is called on to examine for other conditions before the clinician or the surgeon is willing definitely to conclude that the symptomatology is appendiceal in origin. Ureteral stone seems to be the most frequent condition to be excluded. Next in frequency seems to be gallbladder disease and gastric and duodenal ulcer in the upper abdomen. Other conditions which may cause symptoms more or less confusing in the diagnosis are diverticulitis of the colon, inflamed Meckel's diverticulum, early malignancy of the bowel, tuberculosis of the cecum and disease of the spine. Colonic diverticula are easily found, but Meckel's diverticulum is very difficult to detect. Malignant disease is usually demonstrated readily, but early malignancy may be overlooked unless the examiner is on the lookout for it. Tuberculous colitis has been diagnosed frequently, but may be mistaken for malignancy or adhesions. Pelvic conditions, such as ovarian or tubal disease or ectopic pregnancy, are rather beyond the pale of roentgenology as a rule.

An examination of the chest, by fluoroscope at least, should be a part of the routine gastro-intestinal study. Sometimes an adherent or restricted diaphragm will point to a previous pneumonia and pleurisy which were accountable for the supposed abdominal symptoms. We recently found, in a case with obscure lower abdominal pain of long standing, a very much elevated and fixed right diaphragm without enlarged liver or cause above for the phenomena, and which was probably due, therefore, to a previous subphrenic abscess. These findings brought the appendix under suspicion as a possible cause.

5. The frequent coexistence of a diseased appendix and some other surgical condition of the abdomen, such as gallbladder disease, gastric or duodenal ulcer, kidney stone and many others, is well recognized. It would be too great a burden for the roentgenologist to make a routine gastro-intestinal study in every case of appendicitis unless his work was largely confined to that particular field. If, however, the symptomatology is in the least obscure or some other condition is suspected elsewhere in addition, a complete study is likely to justify the surgeon in limiting his exploration to the region of the appendix if no other condition is found, or to direct him to the proper field if a coexisting surgical condition is demonstrated.

THE RELATION OF THE HEART, PERICARDIUM AND THE HEART VALVES TO THE ANTERIOR CHEST WALL

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In the past the descriptions of the usual relationship of the heart and its valves to the chest wall, in the works on anatomy, have been based upon dissections. These have been supplemented in some cases by the insertion of needles in order that the relationship between the surface and the deeper structures might be retained. That this method was not accurate is evidenced by the great variations in the location, for example, of the heart and its valves, as reported by different anatomists.

For example, Gray [1] gives the following description of the heart:

The base looks upward, backward and to the right and is separated from the fifth, sixth, seventh and eighth thoracic vertebrae by the pericardium, esophagus, aorta and thoracic duct.

The apex formed by the left ventricle is directed downward, forward and to the left, and is overlapped by the left lung and pleura; it lies behind the fifth left intercostal space, about 8 cm. from the midsternal line, or, in the male, about 4 cm. below and 2 cm. to the medial side of the left mammary papilla.

The sternocostal surface is directed forward, upward and to the left. It consists of an atrial and ventricular portion, the former being above and to the right, the latter below and to the left of the anterior part of the coronary sulcus. The sternocostal surface lies behind the body of the sternum, the transverse thoracic muscles and the cartilages of the third, fourth, fifth and sixth ribs; owing to the bulging of the heart toward the left side, a much greater part of the surface lies behind the left than the right cartilages. The sternocostal surface is also covered by the pleura and the thin anterior part of the lungs, with the exception of a small triangular area corresponding with the cardiac notch in the left lung. The base of this triangular area is represented by a line on the middle of the sternum from the level of the fourth costal cartilages to the junction of the body of the sternum with the xiphoid process, and the sides by lines from the apex of the heart to the upper and lower ends of the base line.

The right margin of the heart, formed by the right atrium, is rounded almost vertical. It is situated behind the third, fourth and fifth right costal cartilages, about 1.25 cm. from the margin of the sternum.

The inferior and acute margin formed almost entirely by the right ventricle is nearly horizontal and extends from the sternal end of the sixth costal cartilage to the apex of the heart.

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1. Gray, Henry: Anatomy—Descriptive and Applied, Ed. 21, Philadelphia, Lea & Febiger, 1921.

The left and obtuse margin is full and rounded; it is formed, mainly, by the left ventricle, but to a slight extent, above, by the left auricle. It extends from a point in the second intercostal space, about 2.5 cm. from the sternal margin obliquely downwards, with a convexity to the left, to the apex of the heart.

According to Piersol [2]:

The heart may vary considerably in position without being regarded as abnormal, but what may be considered its typical position with reference to the anterior thoracic wall may be stated about as follows: The apex is situated

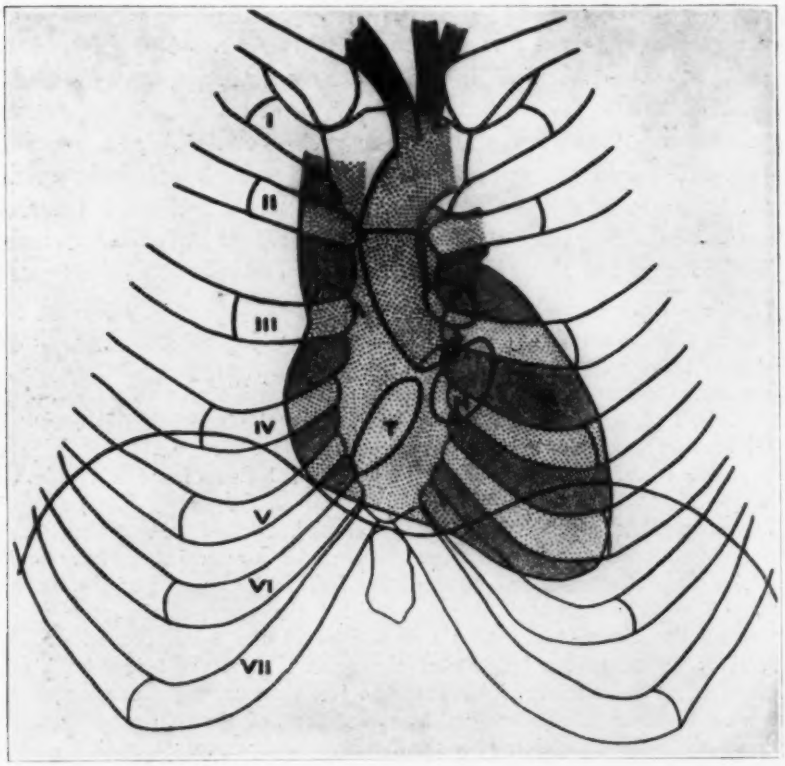

Fig. 1.—Outline drawing of teleoroentgenogram (Fig. 2) and stereoscopic roentgenograms. The position of the valves *T* (tricuspid), *M* (mitral) and *P* (pulmonary) may be noted. The aortic valve is indicated by the beginning of the aorta.

behind the fifth intercostal space, about 8 cm. (3¼ inches) from the median line, this position being median to and slightly below the junction of the fifth costal cartilage with its rib. The level of the base may be approximately indicated by a line drawn from a point slightly above the upper border of the third costal cartilage of the left side, about 4.5 cm. (1¾ inches) from the

2. Piersol, G. A.: Human Anatomy, Philadelphia, J. B. Lippincott Company, 1907, p. 692.

median line of the sternum, to a point on the upper border of the third costal cartilage of the right side, about 3 cm. (1¼ inches) from the middle line. If now the left end of the base line be united to the apex point by a line which is slightly convex toward the left, and a line, markedly convex toward the right, be drawn from the right end of the base line to the junction of the seventh costal cartilage of the right side with the sternum and thence to the apex point, a heart area will be enclosed which corresponds to the outline of the organ as seen from in front.

Fig. 2.—Relationship of the heart and its valves to the anterior thoracic wall. Compare Figure 1; exposure made at a distance of 6 feet (1.8 meters); measurements verified later by dissection.

Considerable importance attaches to the location of the auriculoventricular and the aortic orifices with reference to the anterior thoracic wall. The right auriculoventricular orifice in a typical heart lies on a level with the attachment of the fifth costal cartilages to the sternum, almost behind the median line of that bone and opposite the fourth intercostal space, while the left auriculoventricular orifice is opposite the sternal end of the left third intercostal space. In other words, these openings lie along a line which corresponds with the auriculoventricular groove, and this may be represented by a line drawn from the upper border of the junction of the seventh costal cartilage of the right

side with the sternum to the sternal end of the third left costal cartilage. The right orifice is located upon the line where it is intersected by a line joining the sternal ends of the fifth costal cartilages, while the left one is situated at its upper end.

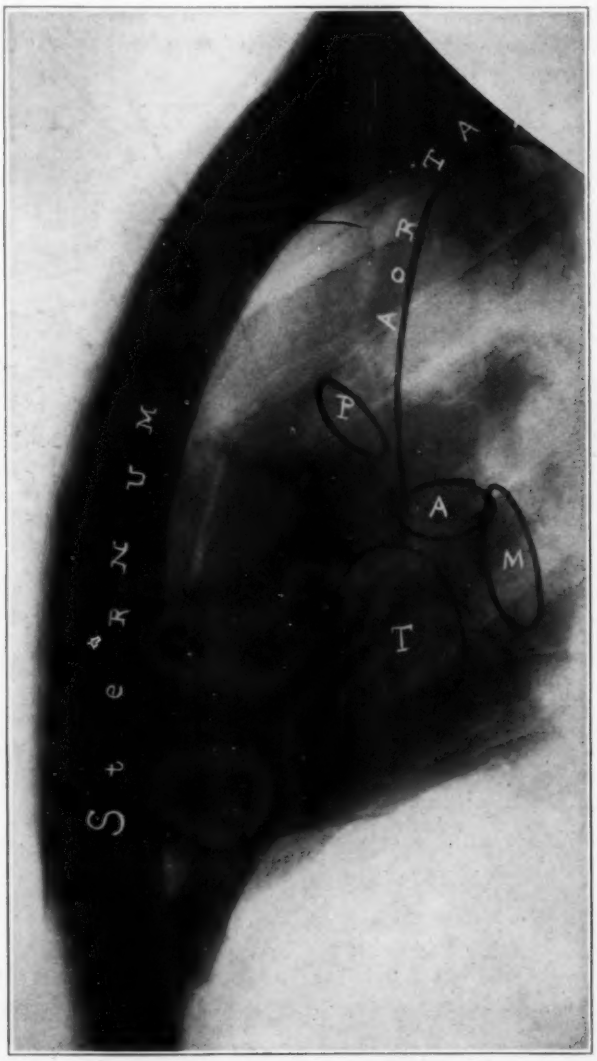

Fig. 3.—Lateral exposure showing the depth of the valves: *P* (pulmonary), *T* (tricuspid), *A* (aortic), *M* (mitral).

The systemic and pulmonary aortic orifices are situated at about the level of the attachment of the third costal cartilages to the sternum, the pulmonary orifice being behind the sternal end of the third left cartilage, while the aortic orifice is behind the left half of the sternum, a little below and to the right of the pulmonary one, the two orifices overlapping for about one quarter of their

diameters. It is to be noted, however, that the pulmonary aorta is directed upward and to the left, while the systemic aorta inclines decidedly toward the right in the first part of its course; and since the sounds caused by the valves which guard the orifices are carried in the direction of the blood stream, auscultation of the pulmonary semilunar valves may be practised over the sternal end of the second left intercostal space, while that of the systemic valves is best performed over the sternal end of the second right space.

Similarly the close proximity of the areas of the left auriculoventricular and systemic aortic orifices, as projected upon the thoracic wall, might lead to confusion, were it not that the course of the blood passing through the two orifices is in opposite directions, and the auscultation of the auriculoventricular orifice is consequently satisfactorily performed toward the apex of the heart.

Considerable variation from the position of the heart, indicated above, may be found. Thus the apex may be situated behind the fifth costal cartilage, or

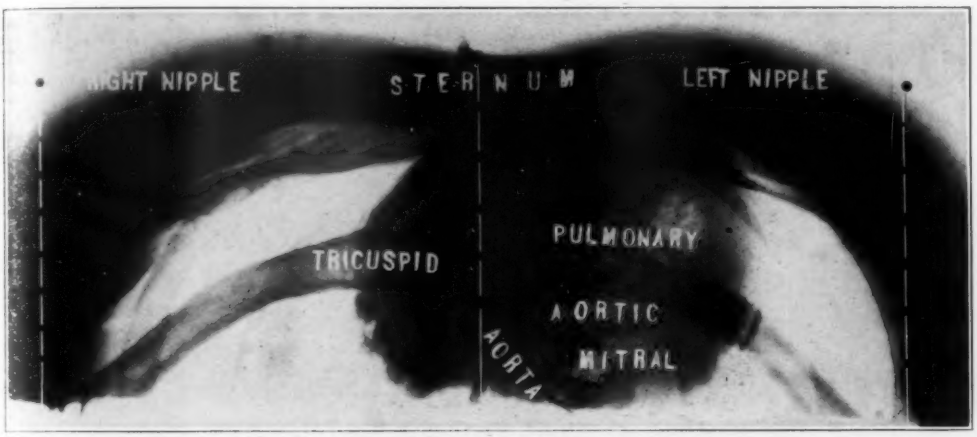

Fig. 4.—Vertical projection showing relationship of valves to median line of the body.

more rarely the sixth, and the pulmonary aortic orifice may occur as high up as the second intercostal space, or as low as the level of the fourth costal cartilage.

The heart naturally has its position altered somewhat during its contraction and during the respiratory acts, and the position of the body will also have some effect in modifying its location. Resting as it does upon the diaphragm, the heart will alter its position somewhat with alterations of that muscle; and since in the child the diaphragm is somewhat higher and in the aged somewhat lower than in the middle period of life, corresponding changes according to age will be found in the position of the heart. It may be noted, furthermore, that the position of the heart as determined in the cadaver will, as a rule, be slightly higher than in the living body, owing to postmortem tissue changes which allow the diaphragm to assume a more vaulted form than is usual in life.

In only one instance have two observers agreed. On further study, this agreement was found to be due to the fact that the data had been transferred from one author to another with due credit.

NEW METHOD OF DETERMINING THE RELATION OF THE HEART AND ITS VALVES

In view of the facts above stated, it was decided, at the suggestion of Dr. H. D. Senior, Professor of Anatomy at Bellevue Hospital Medical College, to attempt a new method. This was accomplished and the results published in Morris' Anatomy and in the Stereo Atlas. The

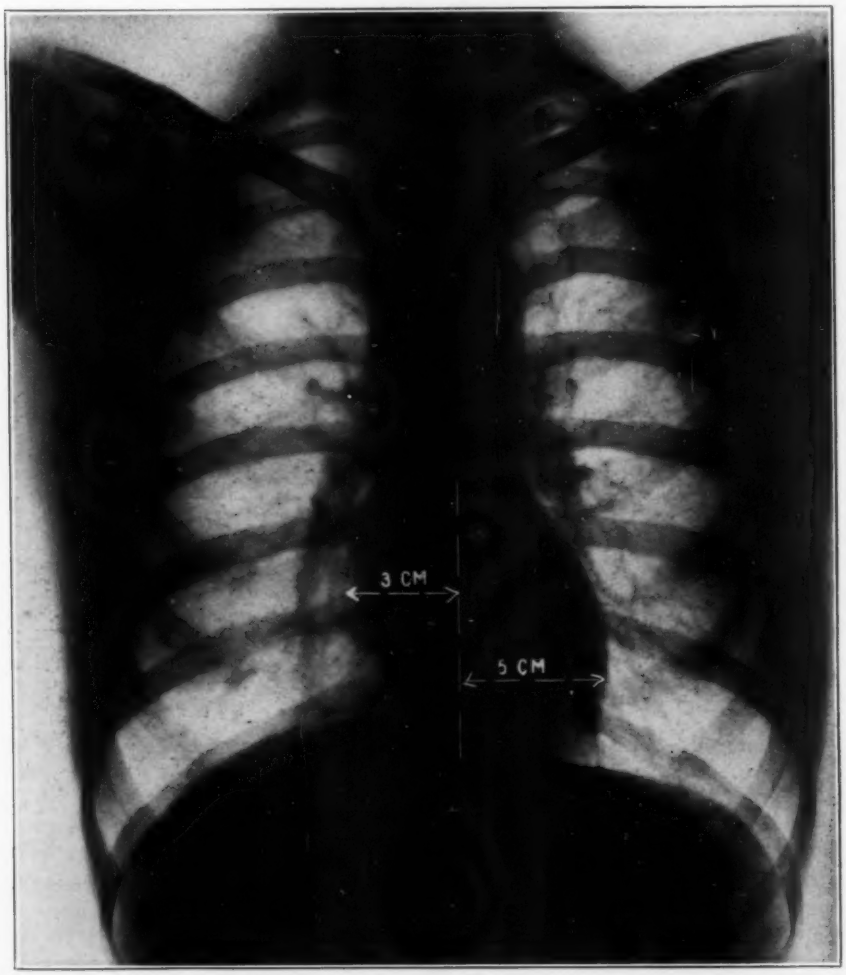

Fig. 5.—Hypoplasia of the heart; the extremely small size of the heart, the transverse diameter being only 8 cm., may be noted.

body was injected through the right carotid artery with equal parts of commercial liquor formaldehydi and water, the injection being begun with the body in the horizontal position and finished with the body in the vertical position. The body, which had been stored in the

horizontal position for some months, was frozen and the thorax removed. The frozen thorax was then cut accurately, by means of a band saw, in the frontal plane so as to open both auricles from behind, without interfering with the contour of the heart. In the intact interior portion of the thorax, the mitral and tricuspid valves were readily accessible. Wires were bent so as to fit accurately the groove corresponding to the attachment of the valves to the heart wall. The wires were placed in position from the auricle, and, in the case of the

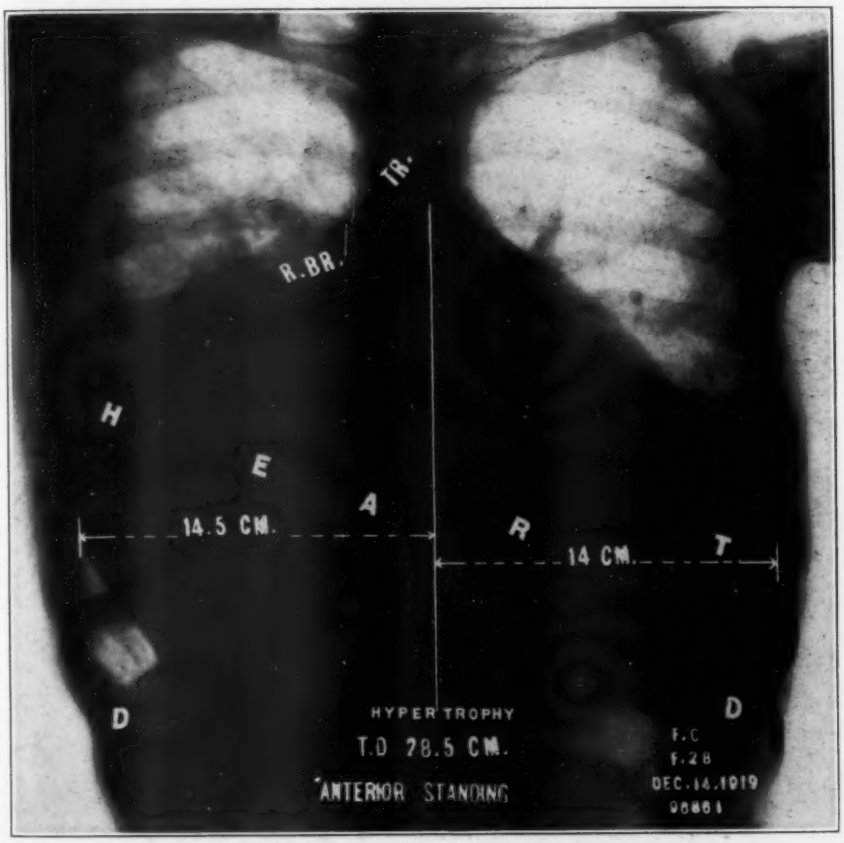

Fig. 6.—Hypertrophy of the heart (transverse diameter, 28.5 cm.) which could be mistaken for pericardial effusion (Fig. 8); the narrowing at the great vessels may be noted. Patient under observation for six years; had rheumatic fever at age of 7; aged 28 at time of this roentgenogram.

tricuspid valve, fixed by means of two sutures. The cusps of both auriculoventricular valves were found to be in apposition. The interior of the aorta was reached through the anterior wall of the left auricle. The region of the pulmonary valve was made accessible by removing the remainder of the left lung and cutting the artery longitudinally

from the left side. Wires were shaped to fit the aortic and pulmonary orifices and placed so that they were in contact with the deepest part of each of the semilunar valve cusps, which provided excellent guides in placing the wires. After placing the pulmonary ring, the cut edges of the vessel came into position. The accuracy of the position of the wires was verified after roentgenograms had been taken.

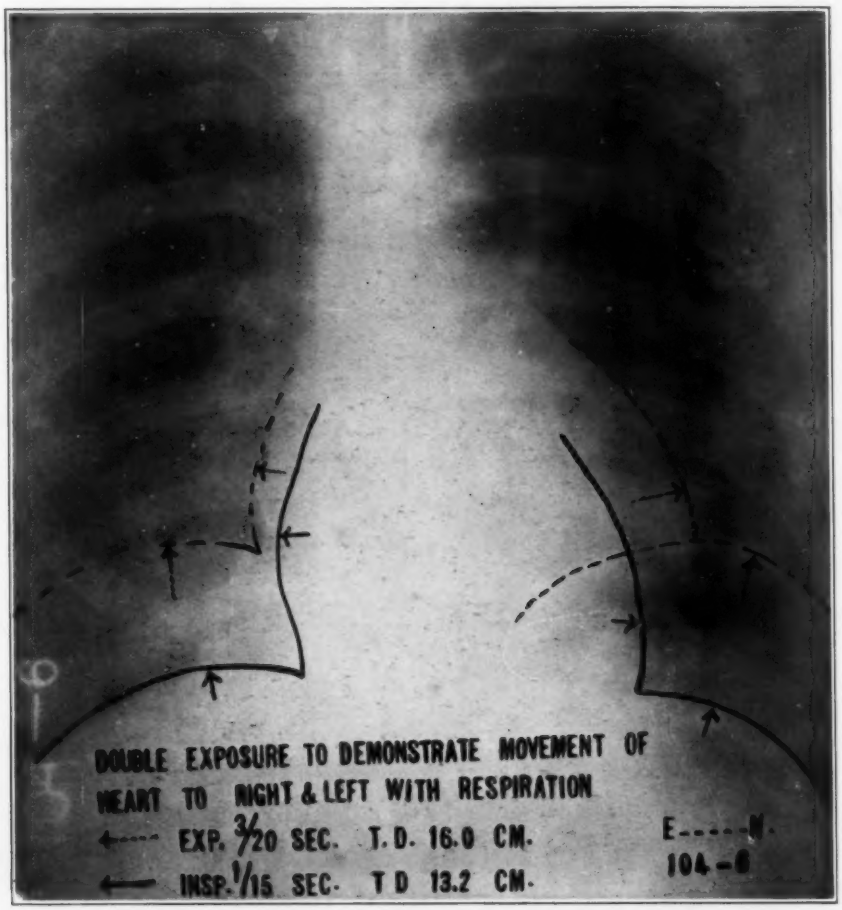
DOUBLE EXPOSURE TO DEMONSTRATE MOVEMENT OF
HEART TO RIGHT & LEFT WITH RESPIRATION
EXP. 3/20 SEC. T. D. 16.0 CM.
INSP. 1/15 SEC. T D 13.2 CM.
E-----M.
104-6

Fig. 7.—The aviator's heart, showing the effect of respiration on the heart: solid line indicates diaphragm and heart at full inspiration; broken line indicates diaphragm and heart at full expiration (difference in transverse diameters, 2.8 cm.). Two exposures were made on one plate to demonstrate the change in size and position of the heart during deep breathing.

The first teleoroentgenograms were taken with the material frozen, the remaining portions of the lungs and liver having been removed after freezing. The parts were so rigid, however, that after the first trials freezing was not repeated. It can safely be said that lack of

rigidity is not a source of error. To minimize optical distortion, the tube was placed 6 feet (1.8 meters) from the object, which was horizontal, with the anterior surface in contact with the plate holder. The tube was accurately centered on a shot, which may be distinguished in the roentgenogram a short distance above the tricuspid ring. The shot is embedded in the skin of the median line of the thorax at the middle of the longitudinal area occupied by the wires.

Fig. 8.—Pericardial effusion; the water bottle shape of the heart area, with the broadening at the great vessels, and obliteration of the usual curves, indicated by the arrow, may be noted.

Stereoroentgenograms were made in the usual way and the subject was also roentgenographed in various positions.

The outline drawing (Fig. 1) was traced from the negative (Fig. 2), most of the doubtful points in which were elucidated by the stereoscope. The left limit of the superior vena cava and a small portion of the upper left margin of the heart, where the picture of the latter is obscured by the root of the lungs, could not be determined with certainty. The

outline is omitted from these regions, but subsequent removal of the heart testified to the approximate accuracy of the dotted lines by which these margins are indicated. Several parts indentified in the stereoroentgenogram have been omitted for the sake of clearness, such, for instance, as the inferior vena cava, and the anterior papillary muscles of the right and left ventricles, and one of the mitral cusps.

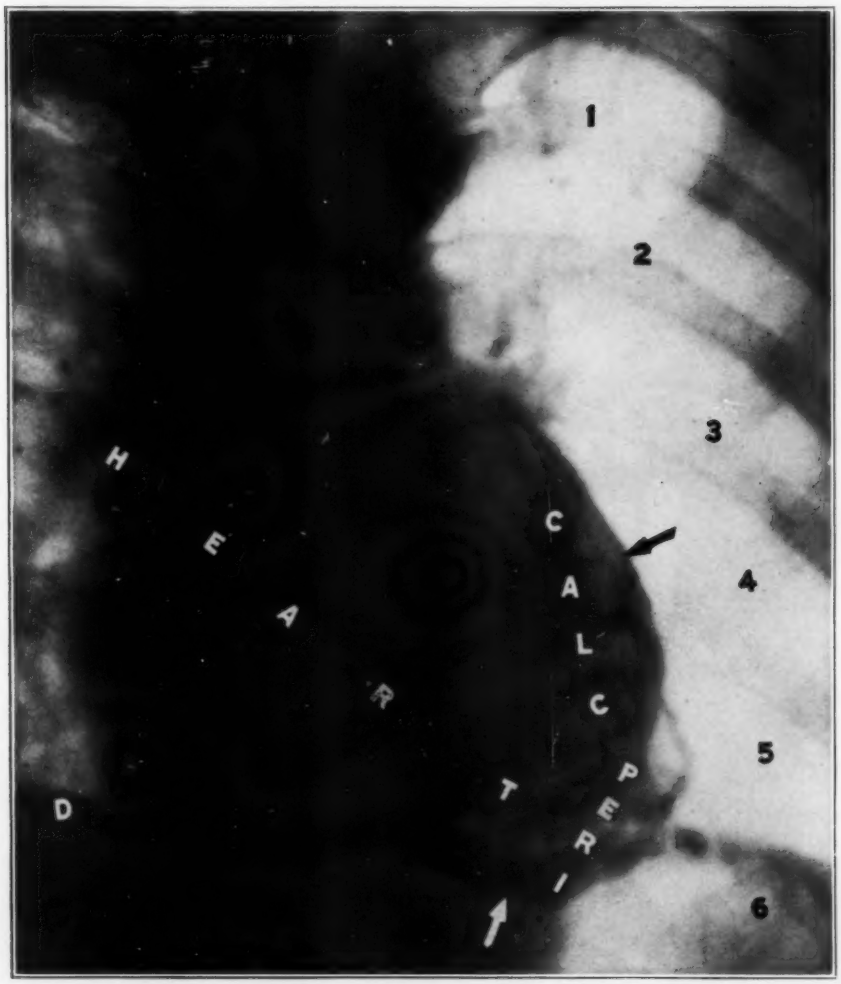

Fig. 9.—Calcified pericardium which may give little or no evidence on ordinary physical examination but is readily detected on roentgen-ray examination.

The apex is in the fifth intercostal space, from 7.5 to 8 cm. (3 to 3¼ inches) from the median line. The base (above) corresponds to an imaginary line (*A*), drawn from a point 1 cm. (2/5 inch) below the second left chondrosternal articulation, and 3 cm. (1 1/5 inches)

from the median line to another point the same distance from the median line, 1 cm. above the right chondrosternal articulation. The margo acutus, or lower border, corresponds to a line (*B*) drawn from the apex through the xiphisternal articulation, to a point on the sixth costal cartilage, 2 cm. to the right of the median line. The right border of the heart may be indicated approximately by an imaginary line (slightly convex to the right), joining the right ends of the *A* and *B*. The left border corresponds to a line (slightly convex to the left), joining the left end of *A* to the apex.

If a line is drawn from the upper margin of the left third chondrosternal articulation to the right edge of the sternum in the fifth intercostal space, the upper end of the line will lie over the center of the pulmonary orifice, and the lower two thirds of it (approximately) will overlie the main axis of the tricuspid orifice. The aortic orifice is immediately to the left of the above line, with its center at the left edge of the sternum, opposite the third space. The mitral orifice is very largely behind the third left interspace; its upper end is behind the third cartilage, its lower behind the left margin of the sternum, opposite the fourth cartilage and space.

Of the orifices of the heart, the pulmonary is the nearest to the anterior thoracic wall; the tricuspid is slightly in advance of the aortic, and the mitral deepest of all (Figs. 3 and 4).

The pericardium follows the outline of the heart closely. The upper end (apex) in this subject extended up behind the sternum, to the lower margin of the first costal cartilage on the right and the upper margin of the second on the left.

The positions occupied by the cardiac orifices may be seen so plainly that it is unnecessary to describe them further. It may be said, however, that all the rings are seen from the lower (anterior) aspect except the aortic, which is seen from above.

Norris and Fetteroff [3] approached the study of the problem with the aid of horizontal sections and coated the heart valves with a lead preparation prior to making roentgenographic studies. This method, it seems to me, while valuable, disturbs the anterior chest wall. Groedel [4] roentgenographed the heart after it had been removed from the body and obtained valuable information in this way.

VALUE OF ROENTGENOGRAMS IN DIAGNOSIS

The accompanying roentgenograms are interesting in that they illustrate certain pathologic conditions. Hypoplasia of the heart has received comparatively little attention. While it is necessary always to

3. Norris, G. W., and Fetteroff, G.: Am. J. M. Sc. **145**:225, 1913.
4. Groedel, F. M.: Arch. Roentgen Ray **17**:86, 1912.

take into account the size and type of the individual, yet several instances of hearts which were distinctly smaller than normal have been encountered (Fig. 5).

In hypertrophy of the heart, the teleoroentgenogram is the best method of determining the amount of enlargement . When of extreme degree, the findings are easily determined (Fig. 6). When the question of minor degrees of hypertrophy or gradual increase of the size of the heart is the question to be determined, extreme care in technic is necessary in order that the effect of respiration, displacement of the diaphragm, etc., may be taken into consideration. This problem was encountered in the study of the aviator's heart [5] (Fig. 7). In pericardial effusion, the roentgenologic examination is of great importance, but the findings must be interpreted with great care (Fig. 8). A case of calcified pericardium gave no physical signs indicative of the condition which was discovered on fluoroscopic examination (Fig. 9). Prior to any surgical procedure involving the chest, a careful roentgenologic examination in various positions should always be made.

5. Le Wald, L. T., and Turrell, Guy: The Aviator's Heart: Roentgen-Ray Studies Under Conditions Simulating High Altitudes, Am. J. Roentgenology **7**:67 (Feb.) 1920.

THE VALUE OF PERICARDIOTOMY IN DIAGNOSIS AND TREATMENT *

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PHILADELPHIA

Diagnosis may be established in obscure conditions occasionally, and permanent relief given to the patient, with only a negligible risk, by a digital exploration of the heart sac.

Philadelphia has been interested in the surgery of the heart and pericardium for years. In 1876 an intern of the Pennsylvania Hospital made a search in its library for literature on pericardial tapping. Some results of this study were incorporated in journal articles [1] and later in Pepper's System of Medicine, 1885, in which an improved form of pericardial aspirating trocar was illustrated. This instrument has proved a useful device. It was described in 1877 and 1881. In October of the latter year, an article, read in Brooklyn, suggested the employment of pericardiotomy to permit the suturing of cardiac wounds.[2]

A suggestive article on cardiac suture by Block [3] appeared in 1882, which I mentioned before the College of Physicians of Philadelphia, in 1883. The present distinguished professor of therapeutics in Jefferson Medical College, Hobart A. Hare,[4] did experimental work in 1886 or 1887, on cardiac wounds, in which he showed that the fatality of these injuries was usually due to mechanical pressure within the pericardium produced by the bleeding.

The earliest American operation for suturing a cardiac wound was performed, if I am not mistaken, by the late Francis Stewart, a young surgeon, who died recently while holding the positions of surgeon to the Pennsylvania Hospital and professor of clinical surgery in the Jefferson Medical College.

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* A recent study of pericardial surgery in the laboratory and wards of the Polyclinic Hospital.

* Read before the Fourth Annual Meeting of the American Association for Thoracic Surgery, Boston, June 6, 1921.

1. Roberts, J. B.: New York M. J. December, 1876; Paracentesis of the Pericardium, Philadelphia, J. B. Lippincott Company, 1880; Tr. A. M. A., 1880.

2. Roberts, J. B.: Ann. Anat. & Surg., December, 1881, p. 250; Medical News, Jan. 13, 1883.

3. Block: Gaz. méd. de Strasb., Oct. 18, 1882.

4. Hare, H. A.: Med. & Surg. Reporter **60**: 1886-1887.

Westbrook,[5] of Brooklyn, in 1882, advocated intentional aspiration of the heart auricle itself to relieve cardiac distention, in cases in which phlebotomy did not seem applicable. Corwin, Dana, Roberts and Leuf, in 1883, wrote on this operation of cardiocentesis; and Senn, in 1885, refers to it in the treatment of air embolism.

F. C. Shattuck and Charles B. Porter of Boston drew attention to clinical and experimental work in cardiac surgery in an important article read before the American Surgical Association in 1897. At that time I[6] advocated a thoracoplastic operation for reaching and dealing with the heart when wounded.

Pericardial tapping as a means of diagnosis was looked upon with increasing favor as these studies continued in various countries. The aid given by the aspirating vacuum attached to the hollow needle or trocar was recognized as increasing the efficiency of the diagnostic operation. The danger of unintentionally puncturing the heart wall and drawing blood from the right ventricle was recognized as being less liable to result in a fatality than missing the opportunity to save life through an early demonstration that the patient was dying slowly from pressure by accumulation of fluid within the pericardial sac. The needle with the internal sliding flexible evacuating cannula, already mentioned, greatly minimized the possibility of wounding the heart itself, even when fluid within the sac was small.

Another corroboration of the nonmortality of aseptic puncture of the normal ventricle, whether accidental or intentional, as shown by Hobart A. Hare and Westbrook, was its occasional occurrence without fatality when searching with the needle for fluid in cases diagnosed as pericarditis with effusion.

I have been surprised in one or two instances of this kind to see the external end of an ordinary aspirating needle pulsate with the heart beat, and blood flow from it without any disagreeable result to the patient except a moderate amount of pain. Striking the fluid through a needle puncture in another place has been followed by escape of the pericardial serum, and the patient has recovered without complication of any kind, notwithstanding the fact that the heart itself was tapped. It is possible, I admit, that the puncture, first made, might have traversed the dome of the diaphragm and drawn blood from the liver. It is needless to say that such a mishap as tapping the heart instead of the pericardial sac is a contingency to be avoided.

Puncture can readily be made under local anesthesia, or even without anesthesia, in rather stolid patients or in those who are partially dulled in sensitiveness or nervousness by imperfect respiration.

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5. Westbrook: New York Med. Rec., Dec. 23, 1882.
6. Roberts, J. B.: Tr. Am. Surg. Assn., 1897, p. 101.

In March, 1904, I aspirated the pericardium in a man, 31 years old, in whom the diagnosis was somewhat indefinite; but pericardial aspiration was advised by the internist in whose care the patient was. The history will show the difficulty of arriving at an exact diagnosis of the intrapericardial condition by tapping. It is quoted here to justify the contention that pericardiotomy may be a better diagnostic operation than paracentesis.

Physical examination gave evidence of an enlarged area of precardial dulness and showed valvular murmurs. The apex beat was

Fig. 1.—Roentgenogram of the pericardium of a cadaver, into which about 740 c.c. of plaster-of-Paris mixture had been injected: *A* indicates the point recommended for aspiration by Rotch, in the fifth interspace, from 4.5 to 5 cm. to the right of the edge of the sternum; *B* indicates the point recommended by Roberts, in the fifth interspace, from 5 to 6 cm. to the left of the median line of the sternum (probably the best point in most cases); *C* indicates the point recommended by Ferrand, at the fifth interspace, vertically below the nipple. The round buttons indicate the nipples.

seen and felt under the left nipple. The dulness extended to the right of the sternum. My belief was that the heart was hypertrophied and that there was not much pericardial fluid. Harsh breathing and some

dulness were recorded in the right chest, posteriorly. There was also heard what was either a pleuritic friction or fine bronchial râles at the base of the right chest, posteriorly. Dulness was also evident at the back of the left side of the chest. Weak pulse, rapid in rate, rapid breathing, dyspnea, and sweating were pronounced. It was not necessary for the man to sit up in order to breathe. My diagnosis was old valvular disease of the heart, with hypertrophy and pulmonary congestion or inflammation.

I, therefore, decided that tapping of the pericardium was not justified, because I was unable to convince myself that there was much fluid in the heart's sac.

The next day I was told that the man's condition was such that the attending physician, an expert internist, thought tapping was very desirable. He himself, unfortunately, could not be present to discuss the operative treatment with me. When I saw the patient, I found more dulness, apparently, than on my first examination. Otherwise I saw no especial change in physical signs.

I, however, accepted the point of view of the more experienced medical man than I, and decided to tap the pericardium with the internal flexible cannula and needle. I entered the chest in the fourth right interspace, close to the sternum, attaching the vacuum chamber after insertion of the needle into the tissues. Three fluidrams (11 c.c.) of slightly red fluid was obtained. The needle and cannula moved with respiration but not with the heart throb, proving that the protected needle point had not punctured the heart.

I then made a second puncture in the fifth left interspace, about 1½ inches (3.8 cm.) below the nipple, to make certain that no large effusion had been missed. The end of the trocar seemed to strike the heart and perhaps to be embedded in the heart muscle, because it moved with such vigor with the heart beats. No fluid, except a few drops of blood, escaped. The pump brought very little fluid, and, after repeated attempts to get fluid, the instrument was withdrawn. Attempts had been made to get fluid by altering the position of the end of the cannula, but none was obtained. It did not feel as if the end of the trocar was free in a cavity of any size. The end of the cannula contained blood clot, and there was a free flow of blood from the wound until it was closed with cotton and collodion. The patient, at one time, complained of severe pain, and it was then that I thought the heart had been wounded.

The next day the patient seemed better; the pulse was stronger, and it was thought that the area of cardiac dulness on the right of the sternum was less. He died three days later.

Necropsy revealed no pleural effusion and no fluid, but a marked amount of lymph in the pericardium. The heart was greatly hyper-

trophied. No mark was found of a wound of the heart, but this would probably have been concealed by lymph deposits.

I had another experience, also with the flexible ended cannula needle, of a somewhat similar kind, in the case of a woman who had come to the Polyclinic Hospital with pericarditis and bronchopneumonia, under the care of Dr. David Riesman.

I aspirated in the fourth left interspace over the apex beat, which could be distinctly felt. The point of puncture was about 3½ inches (8.9 cm.) to the left of the middle line of the sternum, under the left mammary gland, and perhaps through its lower edge. The Roberts pericardial trocar was employed, and worked satisfactorily, the vacuum of the aspirating pump being attached after a little fluid had flowed from the trocar. The introduction of the needle, which was made without attaching the aspirator, was followed by pushing forward the internal cannula. The trocar was introduced to a depth of about 3.5 cm. The point gave the impression of being within a cavity, and the beat of the heart against it was easily felt. The external portion of the trocar oscillated with the cardiac pulsations. Three ounces (85 gm.) of a very bloody serum was drawn off. In order to make a strong

Fig. 2.—Roberts' pericardial aspirating trocar, consisting of a hollow needle and an internal cannula with a flexible end. The cannula is pushed forward after the needle point enters the pericardium.

vacuum, after the small bottle was about half filled, the aspirating apparatus was detached. The contents of the bottle had coagulated so promptly that it took a little time to wash out the bottle and to obtain some of the fluid in sterile test tubes for bacteriologic examination. The aspirator was attached to the trocar again, but no more fluid was obtained. The wound was sealed with cotton and collodion.

Percussion over the upper cardiac region after the patient had been tapped disclosed clearness where previously there had been dulness. The woman, after the operation, seemed to breathe more easily, and had a better pulse. Ethyl chlorid was used to freeze the skin before the puncture was made.

Before the operation there was dulness of the right chest posteriorly, with moist râles. There was marked dulness over the heart. The dull area was somewhat irregularly triangular, with the base downward. This dulness extended into the left axillary region. The dull area seemed to be displaced forward when the patient turned on the right side. The cardiac sounds and impulse were quite distinct in front,

and a friction sound was heard at the base of the heart. This was said to be less than on the previous day. The cardiac sounds were heard posteriorly. There were some râles, posteriorly, in the left side of the chest. The patient was breathing very rapidly and had a weak, rapid pulse, but she was able to lie flat on her back even before operation. The day after operation she was in better condition than on the day of operation, and the cardiac dulness, which had been diminished by operation, was not increased.

Three days later it was determined to make another aspiration because the pericardial sac had evidently refilled. A puncture was made with the Roberts trocar in the fifth interspace, 2¾ inches (7 cm.) to the left of the middle line of the sternum. The aspirating pump was attached, but nothing was obtained, except a very few drops of bloody fluid. The trocar was then withdrawn and found to be plugged. A second puncture was made in the same interspace, 3¾ inches (9.5 cm.) from the midline of the sternum. It obtained by aspiration 4½ fluid-ounces (133.4 c.c.) of dark, bloody fluid. The fluid was much darker and thicker than that obtained a few days before, and did not coagulate so quickly, if it coagulated at all. The trocar moved with the heart beats in both punctures; but not so vigorously as it did on the former occasion. At the last puncture the trocar was buried in the tissues for about 9 cm. The operator received the impression that the point was in a large cavity. At the first puncture the end seemed not to enter a large cavity, but to strike against some solid body within the chest. An increased resonance was obtained by percussion of the precordial region after the operation. The patient died early the next (?) morning.

Necropsy demonstrated the pericardial cavity nearly free from fluid. The heart was covered with shaggy lymph, particularly about its base, and there were adhesions between the heart and pericardium. The first puncture, made on the second day, scraped or went through the edge of the costal cartilage above the interspace.

Upon the front of the heart was a small ecchymosis, without apparent wound, that looked as if it might have been caused by contact with the end of the trocar. This fact could not be definitely confirmed, as the point of ecchymosis was not very marked. There was a considerable amount of fluid in the left pleural cavity, and pleuropneumonia was present. There was some congestion and consolidation of the right lung.

An incised wound of the fifth interspace of the left chest, made with a piece of glass with suicidal intent, which I saw on one occasion, has a bearing on the question in hand. The cut, which was approximately in the nipple line, laid open the pleural cavity and the pericardium. When the patient was brought to the Polyclinic Hospital

there was free bleeding. The intern cleansed the region and stopped the active bleeding. When I saw the man later, there was evidence of some blood in the pleural cavity; but he was in good general condition. I thought it unwise to undertake any active intervention, not knowing that the wound had split open the pericardium. The pleural wound was not large and had been packed with sterile gauze. I believed that if the hemothorax should become infected, I could easily drain and irrigate. The packing in the pleural opening was replaced after a day or so, and later a drainage tube, followed by irrigation of the cavity, was adopted as the line of treatment.

The patient did well for some days; but he died, some time after the injury, of pleuropneumonia. A thorough examination of the region then revealed the pleural opening and also disclosed a clean cut wound, of an inch (2.5 cm.) or more, in the pericardium and a shallow incision in the wall of the heart near the apex, about 1 inch (2.5 cm.) long. This wound was of no special significance in the case, but showed me how easily the heart can be reached for suture in deeper lesions of its muscle tissue.

It is probable that had I seen the patient immediately after the infliction of the wound, exploration with my finger would have revealed the pericardial and cardial damage and would have led to a more radical line of treatment of the injury of the pleura. The young intern naturally, as perhaps I also might have done, gave more attention to arresting the evident bleeding, than of exploring the depths of the wound.

Thorough asepsis might have been followed by suture of both pericardium and pleura, perhaps with safety, and a small cigaret or rubber dam drain inserted superficially.

REPORT OF CASE OF RECOVERY AFTER DIAGNOSTIC PERICARDIOTOMY

History.—The patient whose case prompted the preparation of this paper was a boy, aged 7½ years, who was admitted to the Polyclinic Hospital, July 24, 1919, and discharged, improved in health, Feb. 11, 1920. He had been sent there by the pediatrician of the hospital with a diagnosis of pericarditis with effusion. A condensation of the hospital record is as follows: Tonsils, troublesome since 4 years of age; slight attack of influenza last September; varicella when 4 years old; family history, negative; appears that child had contracted amygdalitis from father and mother, three weeks previous to admission. He was taken to Dr. M., the pediatrician, because of pain in the stomach. Dr. M. sent the child to the hospital with a diagnosis of pericarditis with effusion. Examination of the eyes, ears and nose was negative. Both tonsils were enlarged and the lips were slightly cyanosed. Two teeth should have been removed; otherwise the teeth were in perfect condition. The posterior cervical lymph nodes were palpable, but the anterior nodes were not palpable. Both submaxillary glands were palpable. The lungs were negative. The heart showed an increased area of dulness, extending on the right side to the nipple line and beyond the nipple line on the left side. The heart sounds were fairly

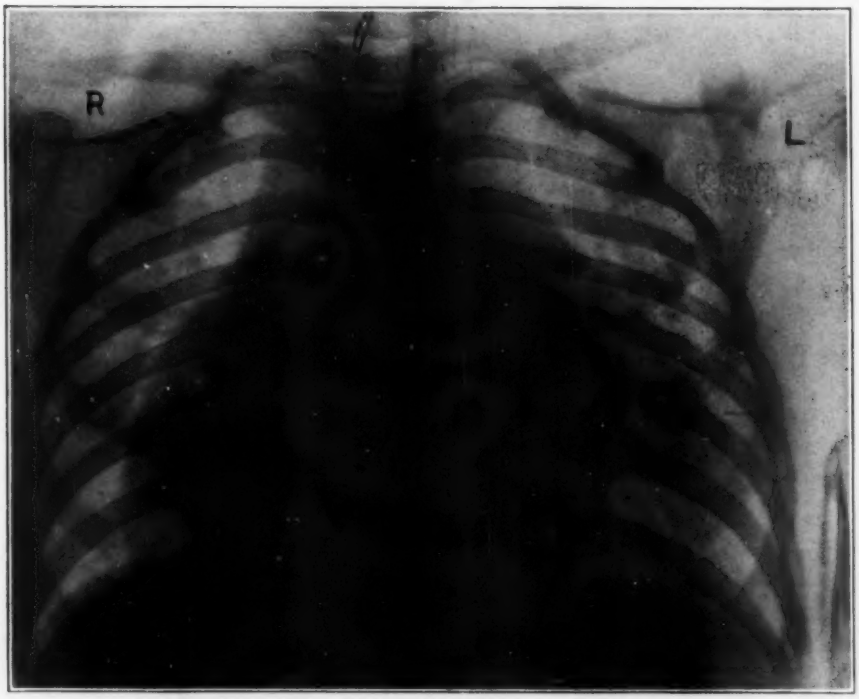

Fig. 3.—Roentgenogram of patient, aged 7½ years, with hypertrophy of the heart, proved by pericardiotomy, which was supposed at the original examination to be pericardial effusion. The shadow of a safety pin is seen on the left side. It served to indicate the left side of the patient.

normal, but an evident to and fro murmur was transmitted to the left axilla mostly. The abdomen and extremities were negative.

The child was under treatment until September. September 9, a roentgenogram was made at the request of Dr. M. The boy was sent to the laboratory with a clinical diagnosis of pericarditis with effusion and left pleural effusion. The roentgenologic report reads thus: "Pericardial effusion; there is a pronounced and overwhelming amount of fluid present and it is well defined by this examination; see no evidence of pleural effusion on either side. See plate." (Dr. W.)

The temperature record for September varied from normal to 99 F., with occasional slight rises to about 100 F., until Sept. 22, 1919. About this time it reached 101 F., irregularly, and oscillated between 100 and 101 F., dropping occasionally to about normal. Late in September, 1919, the temperature rose to 103 F., once or twice. During this month the blood pressure was: diastolic, 70 and systolic, 94. The pulse from the time of admission was about 120, more or less. There was some increase in respiration after the first of August; but before that time it varied from about 20 to 30 per minute, and in September it increased to 50 and 60 per minute. About this time, the pulse rate was from 110 to 125 or 130 per minute, and the temperature varied between 99 and 101 F., rising later to 102 and 103 F.

Sept. 30, 1919, Dr. H. A. McKnight asked me to see the patient in consultation, as he had been asked to tap the pericardium, in his capacity as the surgeon on duty. The clinical diagnosis of pericardial effusion had been made by both the pediatrician and the roentgenologist.

Treatment had consisted of the application of ice to the precordia, and blisters had been caused by cantharidal plaster. Basham's mixture had been given internally, as well as calcium sulphid and acetylsalicylic acid, with orders for weekly urinalysis to be made, and frequent purgatives to be given. No frequent record had been made of accurate auscultation and percussion of the chest, although this examination may have been made by those in charge.

Examination.—Our examination revealed rather loud cardiac sounds, with dulness in the precordial region; but the patient was not especially cyanotic, and as he lay in bed his pulse was rather strong.

Dr. McKnight and I discussed the fact that the clinical examination of the patient did not give the impression that he was suffering from a large pericardial effusion. He was not sitting up in bed panting for breath, and the cardiac impulse did not seem so feeble as it would have been with a large pericardial effusion. On account of the interpretative diagnosis of the roentgen-ray laboratory and the clinical diagnosis of the pediatrician, it was decided to make an exploratory puncture.

Treatment.—An aspirating needle was inserted between the xiphoid cartilage and the seventh rib, but no fluid was obtained. Then an incision was made down through the left fifth interspace, and pleura and pericardium were exposed. The needle was again inserted through the exposed pericardium, and no fluid except blood was obtained. The pericardium was opened by a small incision and the index finger inserted into the pericardial sac. No fluid was obtained, but a very large heart was found.

Considerable trouble was experienced as a result of bleeding from the internal mammary artery, which made the operation more tedious. This was stopped by a hemostatic clamp, which was left on when the wound was sutured. The pleura was torn, probably by a finger, in exploring the cavity of the

pericardium. A piece of sterile gauze was pushed in through the wound in the pleura, and the patient was returned to bed in fair condition. The anesthetist, Miss Bonner, recorded that the patient was a poor subject for ether, his pulse being so rapid at the beginning that it was impossible to count its rate.

Dr. H. A. McKnight performed the operation; Dr. Hawthorne and I assisted. The amount of ether used was 2½ ounces (74 c.c.).

Course.—Digitalis was given after operation, with strychnin sulphate, 1/150 grain (0.00043 gm.), every three hours, by hypodermic injection. Camphorated oil was also given hypodermically. This general stimulating treatment, with camphorated tincture of opium (paregoric), was continued and later changed to Basham's mixture. Sodium bicarbonate and phenyl salicylate were given before meals. The patient, in a short time, reacted and continued to improve above the condition that existed before operation. This improvement was evidently due to change in treatment resulting from the correction in diagnosis, and, perhaps, to relief of pressure on the enlarged heart by the incision in the heart sac, which must have enclosed the large heart tightly, previous to the operation. A revised diagnosis of chronic valvular disease of the heart, mitral regurgitation with decompensation was made. This was evidently the cause of the hypertrophy found at the time of the pericardial operation. Inquiry made at the child's home, many months later, revealed the fact that no apparent disability had resulted from the pericardiotomy performed in 1919 or a later amygdalectomy.

Urinalysis, which was recorded, Dec. 8, 1919, revealed straw colored urine, with a specific gravity of 1.015, acid, no albumin, no casts, no leukocytes and no pus. There was no amorphous sediment, but a few crystals of urates.

The urine when the child was admitted was deep yellow, with a specific gravity of 1.029. acid, slight flocculent sediment, no albumin or sugar. Occasional hyaline casts were observed, as well as epithelial cells and leukocytes, no pus, a few bacteria and some mucus.

The leukocyte count on admission was 9,920; polymorphonuclears, 53 per cent.; transitionals, 32 per cent.; lymphocytes, 1.5 per cent.; large mononuclears, 13 per cent.; eosinophils, 1.5 per cent.; hemoglobin, 76 per cent.; red cells, 4,330,000. About the time of the operation the leukocytes increased in number to 18,400; hemoglobin was 71 per cent.; red cells, 4,600,000. The urine continued to be negative as to albumin and sugar during this entire period.

Valuable additional history was obtained after the operation. The child had been taken acutely ill, June 23, 1919, with high fever, general depression and malaise. He was in bed one week; then he got up and felt better. In July he had an attack of pain in the upper abdomen, diagnosed as gastro-intestinal colic. His breathing had been distressed and rapid. The child never complained of dyspnea and cardiac pain until very recently. He had always had bad tonsils and he had had three severe attacks of tonsillitis. There had been no history of rheumatism, but slight sore throat during the influenza epidemic. The general health greatly improved from week to week.

More than two months later, the patient was etherized with nitrous oxid and ether and operated on for hypertrophied tonsils and adenoids. Miss Bonner reported that the pulse was rapid but fair and that the child took the anesthetic well. The operation was performed in Dr. Ralph Butler's department.

COMMENT

This and other experiences in pericardial surgery have seemed to offer strong evidence in support of the opinion that careful investiga-

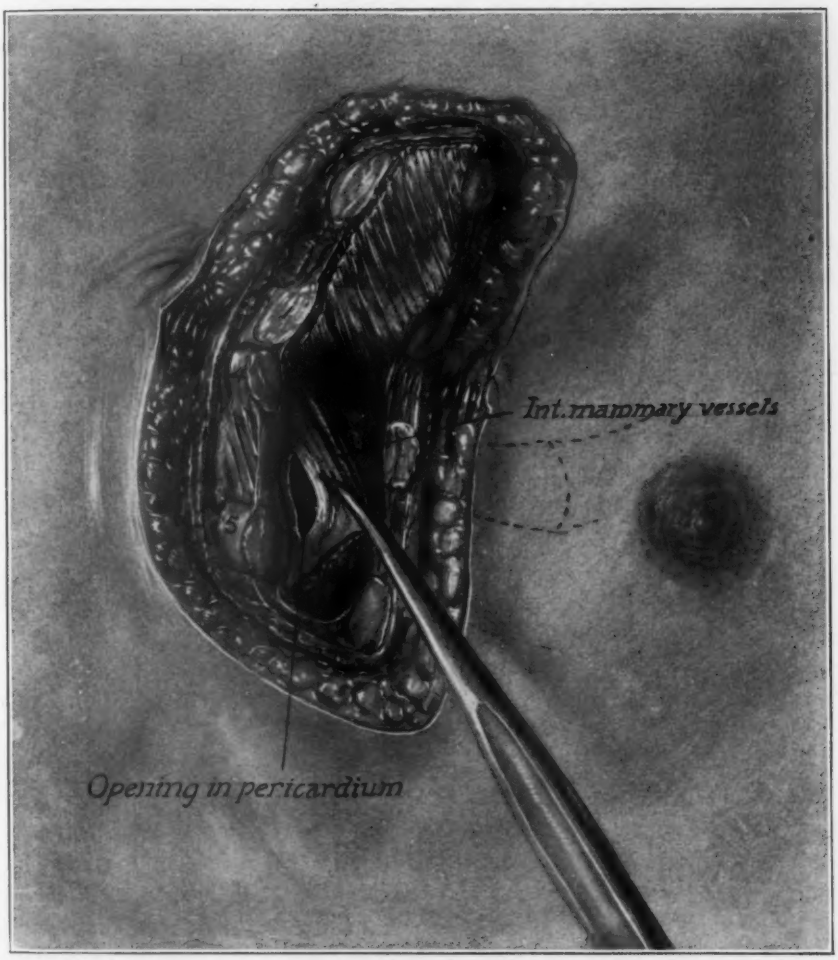

Fig. 4.—Author's chondroplastic method of pericardiotomy by a trap-door excision of the costal cartilages, which prevents injury to the pleura and internal mammary vessels. The flap, consisting of portions of the fourth and fifth cartilages and the attached soft parts, is turned upward, exposing the left lung covered with pleura and the internal mammary vessels. The forceps are holding the vessels and the edge of the pleural sac outward, so as to expose the white pericardium, in which an opening, indicated in black, has been made.

tion should always be made by percussion, auscultation and roentgenographic study before resort is had to tapping, or other surgical attacks, as the line of treatment in suspected pathologic conditions of the heart. They, however, show also the difficulty that may arise in differentiating with accuracy the cause of the objective and subjective symptoms presented to the clinician for diagnostic interpretation.

Recent researches and numerous war experiences in treatment of thoracic wounds and the acknowledged innocuousness of pericardial incisions indicate that it may be at times not only wise, but imperative, deliberately to open the sac of the heart for diagnosis. It will be admitted that this somewhat radical procedure should be adopted in only a comparatively few instances and by surgeons familiar with the surgical anatomy of the precardial thoracic wall.

The differential diagnosis between pericardial effusion, pericardial empyema, intrapericardial bleeding, hypertrophy of the heart, dilatation of the heart, rupture or wound of the heart wall and foreign bodies within the heart sac or embedded in the heart itself may be obscure. The outlook for the patient may become very gloomy. The surgeon under such circumstances, especially when there are various combinations of these pathologic possibilities, is driven to exploration of the interior of the pericardium.

The situation of the patient and the responsibility of the surgeon are then similar to those existing in obscure lesions of the abdominal, pelvic, cranial and pleural cavities. Investigation must be made by endoscopic, visual, and digital exploration of the pericardial sac, and perhaps even of the heart wall and its cavities.

Laboratory researches have apparently proved the possibility of entering even the hollow heart and remedying defects of its valvular apparatus. It is not difficult to believe that small growths within the heart, of syphilitic or other origin, might be excised and small aneurysms of the coronary arteries be surgically obliterated. A rapid and skilful operator might possibly have time to do intracardiac work of value to a suffering patient while the blood current was controlled by twisting or compressing the vessels carrying the inflow of blood.

Operations for withdrawing embolic air from within the heart by aspiration, Trendelenburg's operative removal of blood clot from the pulmonary artery, by means of a pericardial entrance through the second intercostal space, procedures for relieving cardiac adhesions and lessening impeding pressure on the organ's mobility are instances of what have become advances in cardiac surgery.

Hare insisted years ago that the reduction of mortality from cardiac wounds was in its essence simply a mechanical problem; and that it was intrapericardial pressure which the surgeon should seek to remove and then deal with the damage in the muscle of the heart.

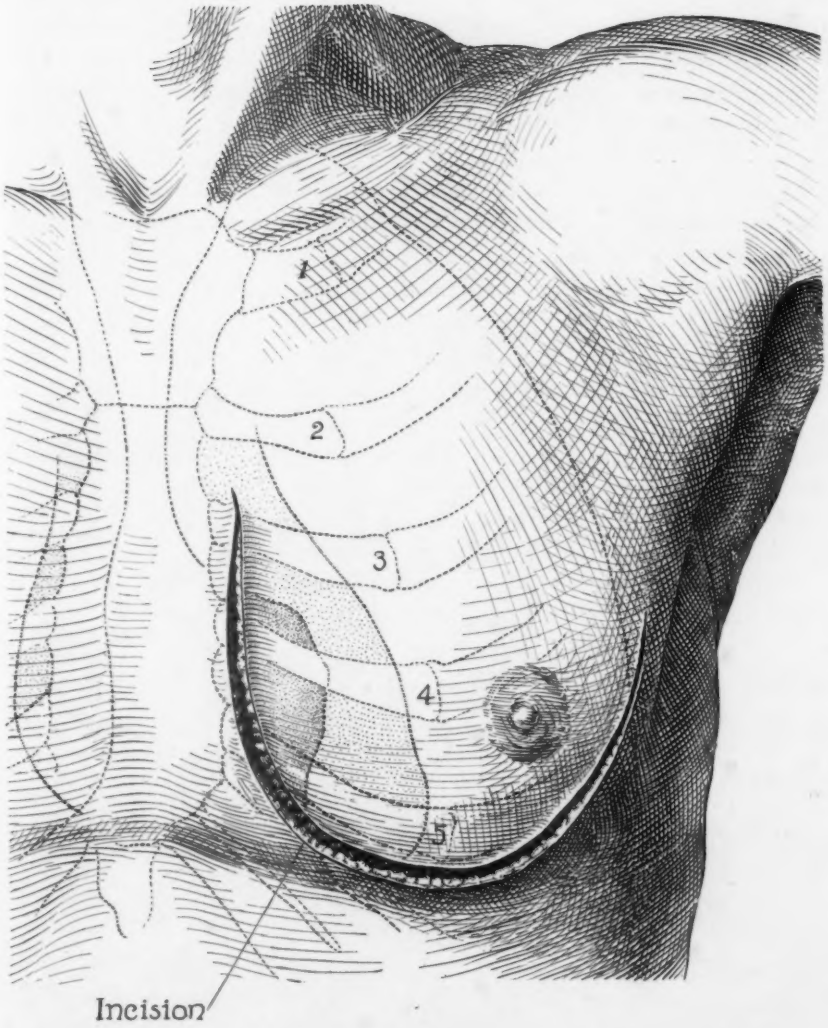

Fig. 5.—Goodman's incision of thoracic wall for exposure of the pericardium. (Courtesy of Dr. Charles Goodman.)

In the case reported in this paper it is possible that the incision in the pericardium encasing the greatly enlarged heart was an important factor in the child's subsequent return to health.

Aspiration of the right auricle and puncture of the right ventricle probably are, as Ballance says, no more valuable and much more dangerous than operative bleeding from the external jugular vein to relieve an overstretched heart. Intentional puncture of the left side of the heart may doubtless be employed with less likelihood of dangerous effects than similar operations on the right side of the sternum to deplete the right side of the heart.

Pericardiotomy is not an operation requiring an unusual amount of surgical skill. It should be performed on the left side of the breast bone, as a routine, in order to reach fluid for the purpose of clearing up a diagnosis or of instituting treatment. I cannot quite agree with Ballance's statement in his recent very valuable Bradshaw lecture that "aspiration of the pericardium should be banished as a surgical practice." Aspiration with a properly selected instrument, such as the dome-shaped trocar of Stewart (?) of Halifax or the pericardial instrument depicted in this paper makes accidental puncture of the left side of the heart very improbable.

A large hypodermic needle, like that of the veterinarian's syringe, will probably always be obtainable and may be used to establish the presence or absence of fluid in the heart sac when pericardiotomy is being considered.

The inner extremity of the space between the sixth and seventh ribs is sometimes absent, because of the contact of the costal cartilages of these ribs, just before they join the sternum. This approximation may be such that it leaves a small slit through which a needle for aspiration may be passed, if it were possible to recognize its exact position, through the overlying soft parts. This difficulty makes aspiration occasionally ineffective because the needle becomes plugged with a piece of cartilage during its passage through the wall.

This difficulty makes pericardiotomy close to the sternum in the sixth interspace often impossible without excision of the sternal ends of the sixth and seventh cartilages. The exact shape of the costal cartilages in this region might be determined and marked on the surface by roentgenographic study prior to aspiration.

Pericardiotomy in this region, as performed by Pool, and permanent drainage for suppurative pericarditis include resection of about an inch of these two cartilages. His method is an excellent one if the surgeon believes it impossible to establish permanent drainage through an opening in a higher part of the pericardial sac. I am rather inclined to believe that pericardial suppuration may be successfully treated by

Fig. 6.—Goodman's triangular flap of thoracic wall raised. The pericardium incised longitudinally affording free access to the heart. The parietal pleura, separated by blunt dissection from the anterior wall, remains unopened. (Courtesy of Dr. Charles Goodman.)

means of an opening made in a higher interspace, where there is more distance between the two cartilages. It is my belief that pericardial pus may be evacuated and the cavity drained and sterilized by frequent irrigation with phenol solution or surgical solution of chlorinated soda, as may be done in pleural suppuration. It will require that the patient with pericarditis should lie in the prone position and have frequent washing out of the cavity. I seldom, if ever, resect the ribs in pleuritic empyema, and I should, therefore, be inclined to do without it in suppurative pericarditis.

Dr. Pool, however, has had experience with his operation by which he excises subperiosteally the ends of the sixth and seventh cartilages and shows excellent results.

Dissections of this region have shown me marked deviation in the relations of the sternal ends of the costal cartilages to one another. The shape of the xiphoid appendix of the breast bone also varies. Operators should make themselves familiar with these aberrations in shape and the intercostal bridges, especially in preparing for aspiration or incision of the pericardium. The forked shape of the xiphoid and its usual attachment near the posterior surface of the gladiolus should be recollected. The occasional foramen in the gladiolus may surprise one.

Diagnostic pericardiotomy should, in my opinion, be employed in the interval between the fourth and fifth ribs or between the fifth and sixth ribs, where there is sufficient space to admit the surgeon's index finger up to the very base. In the fourth space, the middle of this incision should be just at a point a little to the right of, and below, the nipple, close to, but below, the upper edge of the fifth rib. If the fifth interspace is chosen, the wide part between the fifth and sixth ribs is a little farther toward the axilla than in the fourth interspace; the incision should be about 6 cm. long and begin, if the fourth interspace is taken, about 1 cm. from the edge of the sternum. An elliptical flap, with the convexity downward, should be turned so as to expose the entire width of the fourth interspace.

It will be necessary usually to tie the internal mammary artery with two ligatures, the artery then being divided between them. The pleura may sometimes be pushed to the patient's left. If, however, it is opened with the knife or by blunt dissection, no great harm is done. After opening the pericardium and exploring its interior and the heart with the finger, the pleural rent may be closed with a suture or by means of packing. Neither wound of the internal artery nor opening the left pleural cavity will seem to be serious complications to an experienced surgeon. If a large pneumothorax is produced by the mishap of opening the pleura, air may be withdrawn after the wound is closed by

aspiration in the axillary line. Infection of the pleura may occur, however, if pus escapes into it from the opened pericardium. This is more serious.

If the pericardium is believed to contain pus, a small puncture with the veterinary hypodermic syringe may be made before opening the pericardium. If pus is found by this means, a new incision may be made nearer the sternum or drainage may be provided in that region and thus the pleural cavity saved from possible contamination.

Whenever it is necessary to expose the heart for wound caused by a foreign body, a somewhat triangular osteoplastic flap should be turned up by dividing the fourth and fifth cartilages, as suggested by me in 1897, using the intercostal muscles as a hinge; or by the trap door suggested by Delorme, about the same date. Delorme makes the hinge at the edge toward the axilla. Goodman's incision for a flap is lower than that suggested by me; but, I understand, that the intercostal muscle also is used as the hinge for raising the trap door.

[Author's Note.—Since Lauder Brunton in 1902 (Lancet **1**:352) raised the question of surgical attack on stenotic mitral valves, considerable attention has been given to that topic. Drs. Duff S. Allen and Evarts A. Graham published, three months ago (J. A. M. A. **79**:1028 [Sept. 23] 1922) a very valuable study of endocardial operations on this valve by means of an electroscope and a sheathed knife introduced into the cavity of the heart of dogs. Several animals were living several months after such experimental endocardial operations, performed with precision because valve leaflets are cut within the operator's field of vision.]

CHRONIC NONINFLAMMATORY LESIONS OF THE KNEE JOINT *

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The knee joint is the largest joint in the body, and one looks at its structure in the skeleton, only to marvel at its stability during life. The two broad surfaces of the femur and tibia are fitted together only lightly, the round condyles of the femur resting in the slightly concave surfaces of the tuberosities of the tibia. The semilunar cartilages deepen somewhat the shallow fossae for the reception of the condyles, and to a certain extent increase stability, although they do not act as ligaments. They are fibrocartilaginous and, therefore, are more prone to rip or to tear than they are to fracture. The patella is a sesamoid bone, and is of importance in maintaining stability of the joint only so far as its association with the quadriceps muscle is concerned. It is, therefore, evident that the strength of the knee joint must be furnished by a satisfactory system of ligaments, and by such support as may be obtained through the action of the muscles.

For the consideration of the surgeon, the knee joint may be divided into an anterior superior compartment (the suprapatellar pouch), and an anterior inferior compartment (Fig. 1), which may be subdivided into internal and external sections containing the internal and external semilunar cartilage, and a posterior compartment, also subdivided into internal and external sections (Fig. 2). The anteroposterior middle line, in which lie the tibial spine and the crucial ligaments, divides the anterior compartment into two sections, inner and outer. The anterior boundary of these sections is the anterior capsule of the joint, while the posterior boundary may be said to be the posterior margins of the semilunar cartilages (Fig. 2). The posterior compartment is the space bounded behind by the posterior capsule from its line of reflection on the condyles of the femur and the tuberosities of the tibia, and by the bones in front. It is practically obliterated in complete extension, but is larger when the knee is flexed to a right angle. There is usually a mesial septum fastened in the intercondylar notch that divides this posterior compartment into internal and external sections. It is of importance when osteocartilaginous bodies in this situation are to be removed (Fig. 2). Were it not for this septum, one could readily remove a loose body from the posterior external section through an

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* From the Section on Orthopedic Surgery, Mayo Clinic.

* Read before the Idaho State Medical Association, Wallace, July, 1922.

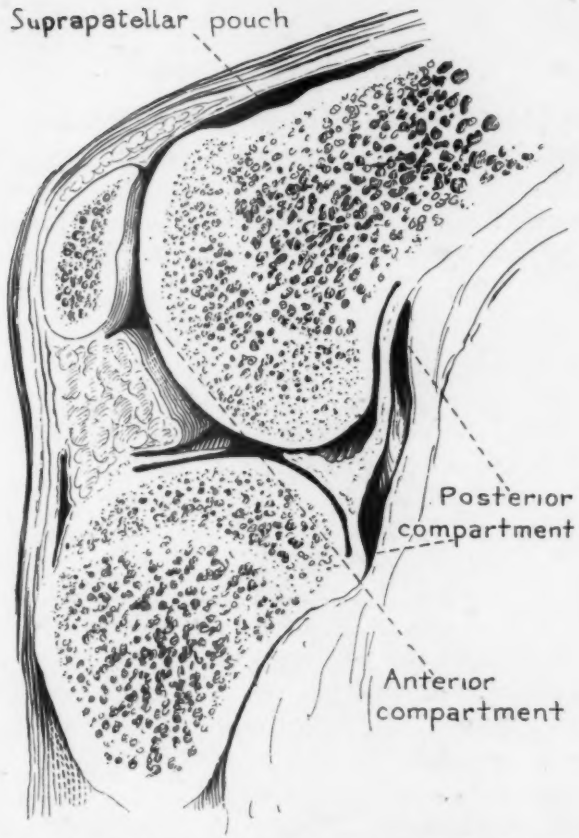

Fig. 1.—Sagittal section through the external condyle of the left femur; for convenience the joint is divided into compartments.

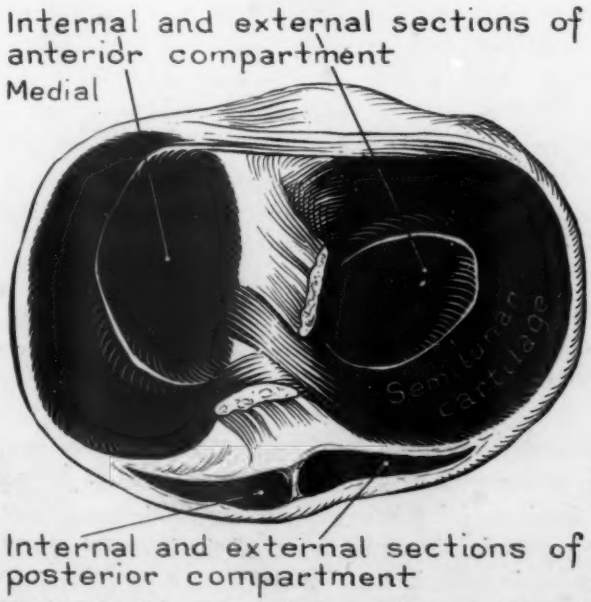
Internal and external sections of anterior compartment
Medial
Semilunar cartilage
Internal and external sections of posterior compartment

Fig. 2.—Head of the tibia with semilunar cartilages; position of the anterior and posterior compartments.

internal posterior incision or vice versa; but usually incisions must be made on both sides if bodies are multiple and are in each posterior section.

The capsule of the knee joint, by a special system of reinforcements, furnishes the ligaments. The external lateral ligament is entirely

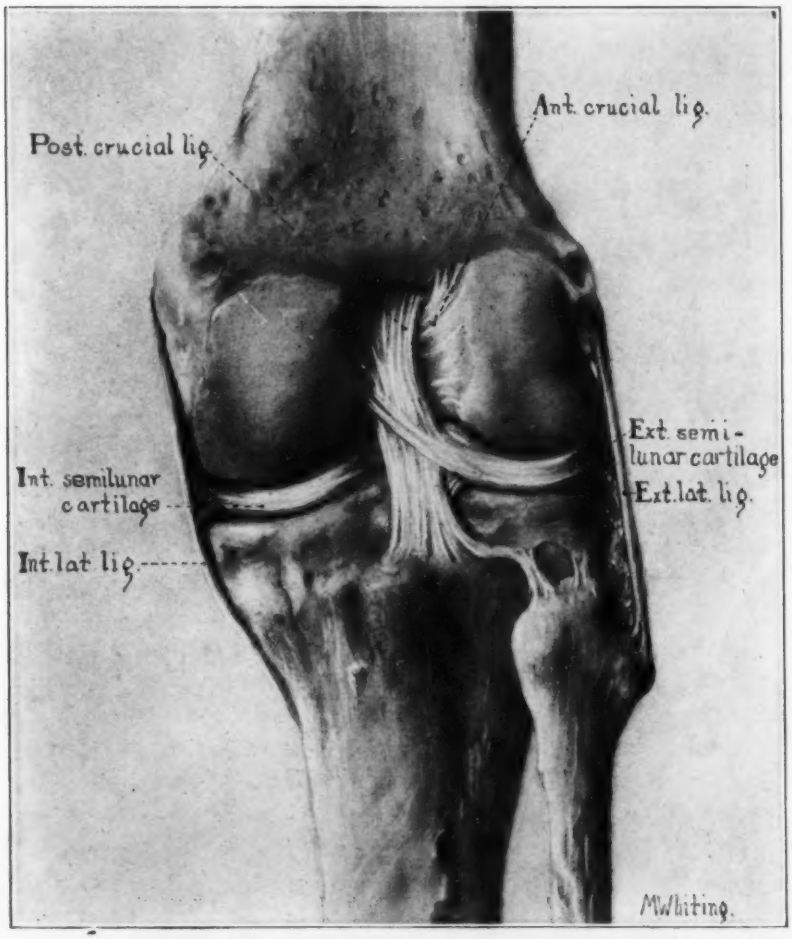

Fig. 3.—Intimate relation of internal semilunar cartilage to internal lateral ligament and the lack of this relation of the external semilunar cartilage to the external lateral ligament.

separate from the external capsule and forms the only really definite ligament in this group of outer ligaments (Fig. 3). The posterior capsule of the knee joint is a weak posterior ligament, and is of but little aid in preventing hyperextension of the knee joint. The internal lateral ligament is most interesting on account of its intimate associa-

tion with, and firm attachment to, the periphery of the internal semilunar cartilage (Fig. 3). It is difficult to define the exact extent of this ligament, as it extends along the entire inner side of the joint. The internal semilunar cartilage, situated in the anterior internal section, is C-shaped, a little more than a half moon. A few fibers of the vastus

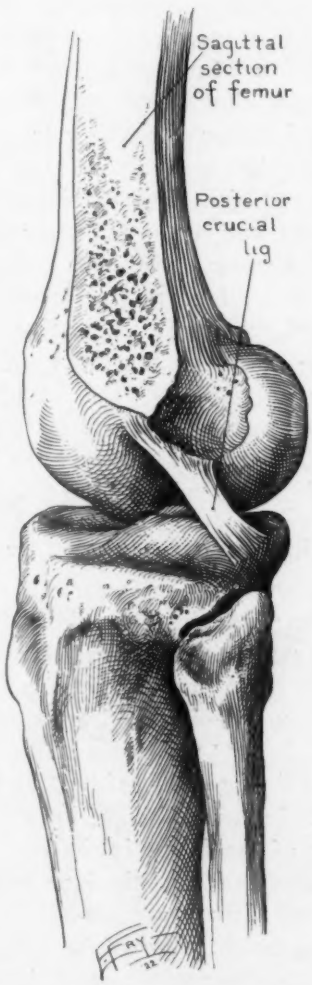

Fig. 4.—Posterior crucial ligament in relation to the condyle of the femur.

internus are prolonged down onto, and are attached to, the internal capsule and, therefore, to the internal lateral ligament. This is of importance because in certain positions of the knee joint, and under certain actions of the quadriceps muscle, these fibers may contract and definitely disturb the normal anatomic relationships of the internal

capsule, the internal lateral ligament, and consequently the internal semilunar cartilage. Therefore, so far as concerns this study, the points of the anatomy of the inner side of the knee joint of particular importance are: (1) The internal lateral ligament is not a definitely developed structure; in reality it is the internal capsule. (2) The internal semilunar cartilage is firmly attached at its periphery to the internal capsule. (3) The vastus internus fibers are inserted low enough on the internal capsule to cause, in certain positions of the knee joint and under certain conditions of muscular contraction, a distortion of the internal capsule and the semilunar cartilage attached to it.

The anterior external section of the knee joint is the portion between the external condyle and the outer tuberosity of the tibia, and contains the external semilunar cartilage. This meniscus is more nearly circular than the internal, is wider, and, again unlike the internal, is quite loosely attached to the external capsule of the joint (Fig. 3). It should, moreover, be remembered that there are no muscular fibers inserted into the external capsule, and, therefore, the relation of the external capsule to the external cartilage cannot be interfered with by any action of the muscles.

The crucial ligaments, situated in the middle of the joint, are of great aid in furnishing stability to the knee joint. The posterior crucial ligament runs from the spine of the tibia upward, forward and inward, to be inserted anteriorly in the external surface of the internal condyle of the femur in the intercondylar notch, thus preventing the tibia from slipping backward on the femur. It also has some effect in limiting extreme flexion; but the impaction of the calf against the thigh is, in reality, the main check to excessive flexion. Therefore, it may be assumed that the chief function of the posterior crucial ligament is to stop the tibia from slipping backward on the femur, or vice versa (Fig. 4).

The anterior crucial ligament runs from the tibial spine backward, upward and outward, to be inserted posteriorly on the internal surface of the external condyle of the femur in the intercondylar notch. This ligament prevents hyperextension of the knee and slipping forward of the tibia on the femur, or vice versa.

The patella is occasionally guilty of both habitual outward dislocation and fracture. Displacement inward is extremely rare, first, because the inner condyle of the femur is high, which prevents it from sliding inward, and, second, because the external capsule, as it runs up to the patella, is shorter and stronger and has not the degree of elasticity of the internal capsule. Genu varum or knock-knee is more common than the genu valgum or bow-leg, particularly in women. Even a slight degree of knock-knee tends to throw the patella outward. This can easily be demonstrated on any patient with knock-knee. If a plumb

line is dropped down the middle of the thigh to the ground while the patient is standing erect, the part of the patella to the outside of the line will exceed that portion to the inside.

The knee joint is superficially placed, and effusions are easily detected. The suprapatellar pouch is connected with the main part of the knee joint, and acts as a safety reservoir for chronic effusions. Not infrequently the suprapatellar pouch of the knee joint is distended so that it extends 10 or 12 cm. above the patella.

The only nerves and vessels of importance about the knee joint are located posteriorly in the popliteal space, and at the head of the fibula where the external popliteal nerve winds its way around to the front of the leg. During operations, care must be taken not to cut the internal capsule too freely, or it may be weakened and fail to serve as an efficient internal lateral ligament.

The knee joint is essentially a hinge, and the motions permitted are flexion and extension. Slight lateral and rotary motions are permitted, however, in certain positions, which is of extreme importance in the production of certain pathologic conditions. Accepting Clark's [1] classification as a basis for recording joint motion, 180 degrees are attained with the knee in full extension. The angle at which the lateral and rotary motions are permitted is between 150 and 170 degrees, and may be spoken of as the "arc of weakness" of the knee joint. The last motion in full extension of the knee is slightly rotary. This is due to the fact that, when the knee is extended and the person is standing, the line of weight-bearing runs through the external condyle of the femur and the external tuberosity of the tibia. As the movement of extension is completed, the internal condyle rolls slightly forward and outward on the internal tuberosity of the tibia.

Hyperextension of the knee joint is limited chiefly by the anterior crucial ligament, but this fact is of little practical importance in this study. The posterior crucial ligament, however, limits the sliding backward of the tibia on the femur, and is of importance since many times persons walking or running meet obstructions, such as a bump on the shin, which block the forward motion of the leg. The body above the knee then tends to go forward and is stopped chiefly by the action of the posterior crucial ligament (an important point in considering the etiology of loose bodies in osteochondritis dissecans) until full extension is reached, when the anterior crucial ligament, the posterior capsule, and the hamstrings are called into play. The foregoing brief review of the anatomy and physiology of the knee joint forms a foundation for the points under discussion: (1) sprains; (2) rupture

1. Clark, W. A.: A Protractor for Measuring Rotation of Joints, J. Orthop. Surg. **3**:154-155 (April) 1921.

of the crucial ligaments; (3) intra-articular fracture of the knee joint; (4) recurring dislocation of the patella; (5) old ununited fracture of the patella, and (6) intrinsic mechanical derangement, due to the semilunar cartilages and loose bodies.

SPRAIN

This condition of the knee joint is not uncommon, particularly in persons participating in active sports, such as football, baseball, tennis and hurdling. The internal lateral ligament is involved in most instances. The differentiation of damaged internal semilunar cartilage and sprain of this ligament is not always easy; but there is no locking with a sprain, and, as a rule, a full range of passive motion is permitted. Effusion may follow either condition, but it more often follows injury to the cartilage. Rest in the extended position for a few days, followed by baking and massage, usually relieves the patient. When pain and tenderness persist, raising the inner side of the sole and heel often affords great relief by removing the strain from the internal lateral ligament.

RUPTURES OF THE CRUCIAL LIGAMENTS

From time to time, articles have appeared in the literature, particularly in the English literature, on the restoration of ruptured crucial ligaments. The objective symptoms are apparently quite definite. If the anterior crucial ligament is torn, hyperextension of the knee is permitted and the femur slides backward on the tibia, or the tibia may slide forward on the femur. When the posterior crucial ligament is torn, the femur may be pushed forward on the tibia, or the tibia backward on the femur. Rupture of these ligaments occurs rarely. I have yet to see a patient with a long-standing disability that could be traced definitely to ruptured crucial ligaments. Therefore, it would appear that the condition is infrequent, and, at least, that the danger resulting from ruptured crucial ligaments has probably been overestimated. I have treated a few patients who had clearly demonstrable ruptured crucial ligaments at the time of the original injury; but by merely placing the patient's leg in a plaster-of-Paris cast, in a slightly flexed position, excellent function has been obtained.

THE INTRA-ARTICULAR FRACTURES OF THE KNEE JOINT

Severe direct trauma to the knee joint may produce fracture of either the internal or external tuberosity of the tibia or of the condyles of the femur. I speak of this condition because patients are often seen who, following such an injury, complain of arthritis, with pain on motion. Very little can be done for such patients, short of an arthrodesis, which most of them, quite properly, will not permit. In

a consideration of the effect, the cause also must be considered, and the question comes up as to whether much can be done when the fracture is first sustained. As a rule, these fractures are the result of severe trauma, the spongy bone is crushed, and, unless the displacement is marked and accompanied by little destruction of bone substance, it is very doubtful whether even an open operation would secure any better replacement of the fragments. Such cases are troublesome to handle, and, as I have said, in this particular type of injury, prolonged fixation in a cast or splint is prone to leave a stiff joint. Early motion is essential, and if it can be carried out under extension, the pain is less severe. The use of a modified Thomas splint with a joint at the knee is convenient. The regular measures of physiotherapy should be persisted in until soreness leaves the joint. After that, free, active use is the best. Many patients are left with more or less permanent disability.

RECURRING DISLOCATIONS OF THE PATELLA

The patella always dislocates outward. Patients may insist that the dislocation is inward, believing that the prominent internal condyle of the femur, which is so noticeable during the dislocation, is the patella. Many operations have been devised for this condition, and all have been more or less satisfactory. The method I have found quite satisfactory is relatively simple, that is, merely reefing the inner capsule, and overlapping it broadly after lengthening the outer capsule. It is not necessary to open the cavity of the knee joint, although there is no serious objection to doing so. Dislocations of the patella are more commonly seen in women; in many instances, there is undoubtedly a familial tendency. Albee [2] advocates raising the outer condyle of the femur by placing a wedge-shaped piece of bone in it. He contends that the dislocations are the result of malformation due to imperfect development of the external condyle, and there seems to be a foundation for this argument.

OLD UNUNITED FRACTURES OF THE PATELLA

Such fractures, with wide separation of the fragments, are difficult to treat. The disability may be great; on the other hand, certain patients accommodate themselves remarkably well to the condition. The object of the treatment is to obtain bony union. A common fracture is one in which the lower fragment is small and the upper fragment is large, the distance between the fragments being 6 or 7 cm. It seems almost impossible to bring these fragments together, as the quadriceps will not stretch enough to permit it, and there is absolutely

2. Albee, F. H.: Orthopedic and Reconstruction Surgery, Philadelphia, W. B. Saunders Company, 1919, p. 627.

no stretch in the patellar ligament. I make a long straight incision in the middle line, expose the fragments regardless of the degree of exposure of the joint, and freshen the ends of the fragments until good bone is reached. Not infrequently, the lower fragment will be tilted so that the fractured surface faces forward. In attempting to bring the fragments together, little can be gained by lengthening the patellar tendon. Therefore, the upper fragment must be brought down

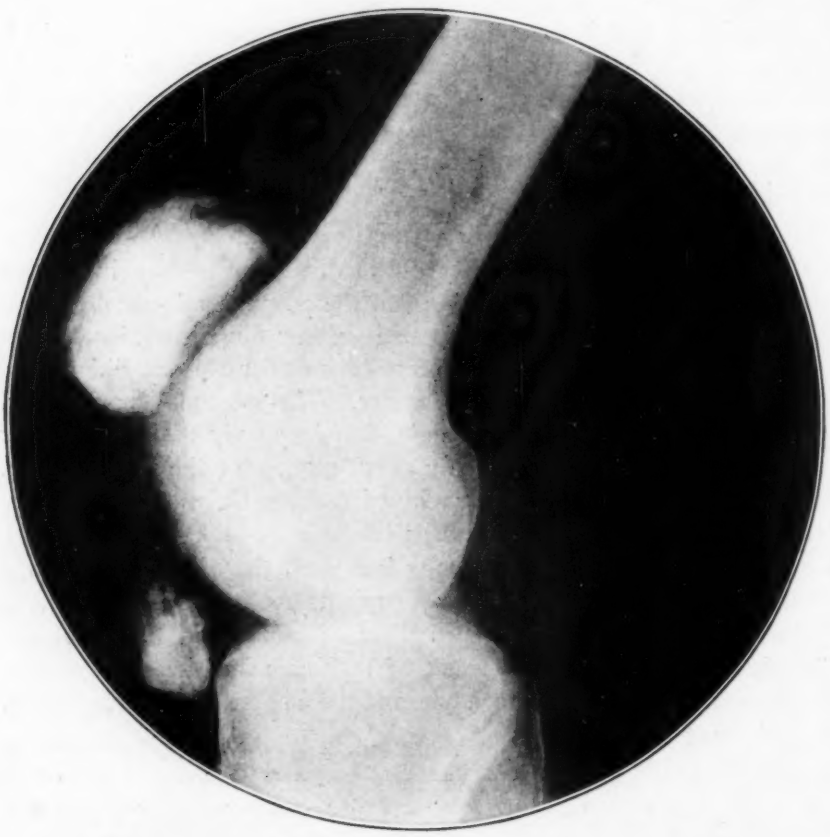

Fig. 5.—Ununited fracture of the patella of two years' duration.

to the lower, even if it is necessary to dissect the upper entirely free from its attachments, making a veritable bone graft. The gap left by the patella, where it is removed from the quadriceps, is obliterated by sewing the muscle and fascia together; tissue is sewed around the patella in its new position, and the coapted fragments are held in place by the aid of beef bone screws (Fig. 5). The main point to be remembered is that the fragments must be brought together without

tension, no matter what material is used to hold them, beef bone screws (Fig. 6), kangaroo tendon, or wire. In the after-care, slight passive motion is commenced in about four weeks, and, soon after, slight active motion is encouraged. It is true that it takes time, probably six months or a year, for flexion to a right angle to be obtained; but satisfactory motion almost invariably returns.

INTRINSIC MECHANICAL DERANGEMENTS OF THE KNEE JOINT

The semilunar cartilages are the most common cause of mechanical derangement, and the internal semilunar cartilage is by all means the most common source.

A great variety of tears in the internal semilunar cartilage has been described and much has been written on this subject by English authorities.[3] Morison[4] has described in detail the various types of fracture commonly met. One type in particular, the bucket handle, named because of its resemblance to the old fashioned leather handled bucket little known in America, seems to be the most common. Perhaps the more appropriate term for such a fracture or tear would be the loop type of tear. The cartilage, which is torn longitudinally near its attachment to the internal capsule in the middle three-fifths, is left attached at the anterior and posterior one-fifth, and the loop thus formed lies in the intercondylar notch (Fig. 7). This position of the loop prevents full extension of the knee and causes locking. The internal semilunar cartilage is the cause of mechanical derangement probably from twenty to thirty times more often than the external. Sir Robert Jones[5] has said that a damaged internal semilunar cartilage may cause symptoms on the outer side of the joint. If the external cartilage is at fault, it is more likely to be detached at its periphery and crumpled, although it may also be torn.

When the knee is flexed at an angle of about 160 degrees and the foot everted, throwing the body weight on the leg causes a strain on the internal lateral ligament. In this particular position, slight lateral mobility is permitted, and the semilunar cartilage is placed deeper in the joint than in any other position, thus rendering it more liable to be caught by the internal condyle of the femur as it rolls down during the act of extension. The final part of extension has in it a slight

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3. Jones, Robert: Notes on Derangements of the Knee, Based upon a Personal Experience of Over Five Hundred Operations, Ann. Surg. **1**:969-1001, 1909; Internal Derangements of the Knee, Lancet **2**:297-300, 1914. Martin, quoted by Morison, R.: Injury to the Semilunar Cartilages of the Knee, Lancet **1**:604-607, 1909; Injuries to the Semilunar Cartilages of the Knee-Joint, Clin. J. **42**:1-7, 1913.

4. Morison, R.: References given in Footnote 3.

5. Jones, Robert: References given in Footnote 3.

Fig. 6.—Patella united and held by aid of beef bone screws.

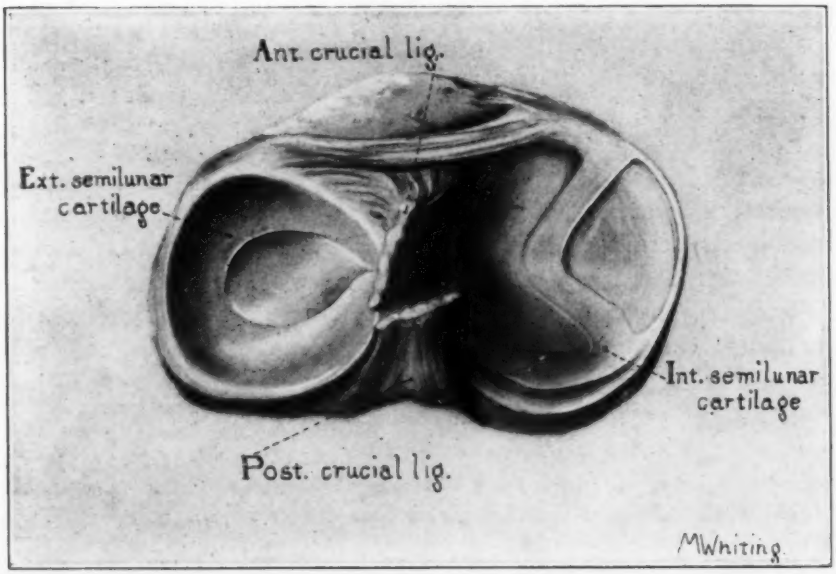

Fig. 7.—The common type of tear, called by Rutherford Morison the "bucket handle fracture"; the loop prevents extension.

screwing, twisting motion on the part of the condyle of the femur, a movement particularly liable to catch the internal semilunar cartilage. If this happens, the act of extension must be stopped at once, which is exceedingly difficult, or something will give way. The cartilage will tear from its moorings on the internal capsule, or, as usually happens, it will rip or tear in its substance. The type of tear or fracture of the cartilage depends on the manner in which it is caught.

The external semilunar cartilage, because of its loose attachment at the periphery to the capsule, has a certain laxity that the internal meniscus lacks, and usually manages to slip out of the way if threatened with crushing by the external condyle. If it is caught, however, it tears loose from its moorings before its substance tears, owing to its loose attachment to the capsule. The symptoms produced by injury to the external semilunar cartilage are variable. Extension or flexion may be prevented, depending on the exact position of the crumpled cartilage.

The story commonly told by the patient who presents himself with derangement of the knee joint attributable to the semilunar cartilages, particularly the internal, is more or less typical. The injury usually occurs during some active pursuit, either work or play. When it occurs, the knee is partially flexed and the foot everted, thus throwing the strain on the internal side of the knee joint, and, as extension is attempted, sharp pain is experienced. The patient may grasp the knee and fall to the ground, fairly writhing in pain. He often speaks of the knee as being dislocated. Effusion is fairly rapid in onset, and sometimes quite extensive; pain persists, and, unless the cartilage is reduced, may last for several days. If a physician is not available, the patient may get somebody to pull his leg; a sudden snap will be felt, and immediate relief experienced. Recurrences are common. The patient may say that during the attack a protuberance may be felt in the anterior internal aspect of the knee joint. The knee joint should not be opened if there has been but one attack, unless, after manipulation, a satisfactory reduction cannot be obtained.

A patient who has had recent locking may need an anesthetic, but this is a matter to be determined in each case. The patient should be on his back, with the thumb or finger of the surgeon placed over the anterior aspect of the internal semilunar cartilage and the knee flexed. As the knee is extended rapidly, pressure being steadily exerted over the anterior extremity of the cartilage, the cartilage may slip into place. If the patient is not under an anesthetic, a great deal of reliance should be placed on whether he feels that things are right in the joint. If complete extension cannot be obtained by manipulation, and the patient still insists that the joint does not feel right, an exploration is justifiable, and, in most cases of this character, the loop type of tear will be found.

In some instances, it is difficult to determine whether the symptoms are due to damage of the internal semilunar cartilage, or of the external; but, as a rule, if the internal semilunar cartilage is involved, the symptoms are confined to the inner side of the joint, and if the external semilunar is involved, they are confined to the external side, although variations from this rule may be found.

When the lockings are so frequent as seriously to annoy the patient, surgery should be resorted to, although no set rule can be followed with regard to the number of lockings that determine this point. The anterior internal incision is the incision of choice for removing the internal meniscus, and the anterior external incision for removing the external meniscus.

The aseptic measures required in operations on the knee joint are, I believe, no more or less than those necessary for any aseptic surgery. It has been my experience that, if the rigid technic common to all properly conducted operations is observed, there is no necessity for the excessive precautions often followed in operating on the knee joint.

The knee is washed and shaved and an alcohol dressing applied the day before the operation. In the morning, the patient is brought to the operating room, the dressing removed, and the ordinary benzene and iodin preparation carried out. The operation is performed with the tourniquet. Skin towels are used, and the cartilage is carefully handled with instruments. If occasion demands, however, I have never hesitated to introduce the gloved finger into the knee joint. More than 300 mechanically deranged knee joints have been opened in the Mayo Clinic without infection. I do not believe that the technic at the time of operation is responsible for most surgical disasters due to infections; more often the cause of these infections can be traced to inefficient preparation and sterilization of the materials used. After the injured meniscus has been removed, the wound is closed in the ordinary manner, layer by layer, with silkworm and ordinary dermal sutures for the skin. A plaster-of-Paris cast is applied and worn for one week.

Another cause of mechanical derangement is the presence of osteocartilaginous loose bodies.[6] These bodies produce locking or derangements of the joint by slipping between the joint surfaces and becoming caught. As a rule, the locking is only transient, and the following effusion is less in amount and the pain less acute than in the locking due to the semilunar cartilages. These loose bodies are produced in various ways, and they are of chief interest when considered from an

6. Henderson, M. S.: Loose Bodies in the Elbow-Joint, J. A. M. A. **71**: 177-180 (July 20) 1918; Osteocartilaginous Joint Bodies, Railway Surg. J. **25**:49-53, 1918; Loose Osteocartilaginous Bodies in the Shoulder-Joint, Am. J. Orthop. Surg. **16**:498-500 (Dec.) 1918.

etiologic point of view. There are three definite conditions causing their formation; (1) osteochondritis dissecans, (2) hypertrophic arthritis, and (3) osteochondromatosis.

In osteochondritis dissecans, there are rarely more than one or two bodies which arise from the internal condyle of the femur (Fig. 8), internal and anterior to the insertion of the posterior crucial ligament.[7] Koenig,[8] in 1887, described the condition and attributed it to

Fig. 8.—Osteochondritis dissecans, showing loose body lying in its cavity on the internal condyle.

a blockage in the end-artery supplying this area on the internal condyle. Other authorities have attributed it to trauma alone, but trauma per se seems an insufficient cause. In such cases the joint surfaces of the knees are peculiarly brittle; and not infrequently the condition is

7. Ridlon, J.: Osteochondritis Dissecans, J. A. M. A. **61**:1777-1779 (Nov. 15) 1913.

8. Koenig: Ueber freie Körper in den Gelenken, Deutsch. Ztschr. f. Chir. **27**:90-109, 1887-1888.

present in both knees. Attention has been directed to the fact that the posterior crucial ligament definitely prevents backward displacement of the tibia on the femur, or forward displacement of the femur on the tibia. It may be that because of the constant pull thus thrown on the crucial ligament, and from it to this area, for example, in walking downstairs, this portion of the condyle becomes devitalized

Fig. 9.—Loose bodies due to hypertrophic arthritis.

in a person with brittle joint surface, and a piece becomes loosened. This, however, is only a partial explanation. Freiberg [9] has recently

9. Freiberg, A. H.: Osteochondritis Dissecans, unpublished. Freiberg, A. H., and Wooley, P. G.: Osteochondritis Dissecans; Concerning Its Nature and Relation to Formation of Joint Mice, Am. J. Orthop. Surg. **8**:477-494, 1910-1911.

contended that the spine of the tibia, by abutting against this area, might have something to do with the production of loose bodies. Uncommonly, the external condyle may form loose bodies. Lamson [10] has reported one arising from the tibia. Blanco [11] reported a case in which hypothyroidism was present and might have been a factor.

In hypertrophic arthritis, loose bodies may be produced by the marginal osteophytic growths breaking off and dropping into the joint.

Fig. 10.—Multiple loose bodies due to osteochondromatosis.

They wander about in the fluid and increase in size (Fig. 9). If the bodies are due to hypertrophic arthritis, four, five, or even more, may be present in a joint; this is more usual in elderly persons.

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10. Lamson, O. F.: Movable Bodies in the Knee-Joint, Surg., Gynec. & Obst. **33**:490-493 (Nov.) 1921.

11. Blanco, P.: Report of a Case of Loose Osteocartilaginous Bodies in the Knee-Joint, J. Orthop. Surg. **3**:104-108 (March) 1921.

In osteochondromatosis (Fig. 10), the synovial membrane takes on an unusual property of forming osteocartilaginous bodies.[12] The bodies in such instances may reach a large number; the knee joint feels like a sack of marbles. Rare cases have been recorded in which hundreds of bodies have been removed from one joint. Why this occurs is difficult to determine. There may be an early history of trauma; but in studying the development of the knee joint in the embryo, it is found that the synovial membrane has developed in the same mesial layer of the blastema, as have the cartilage and bone making up the joint, a fact that affords possible explanation. In the development of the embryo, cells may have become misplaced which, later in life, take on properties not familiar to the normal cells, and produce cartilage and bone. The condition may well be likened to a benign neoplastic tumor.

The presence of the bodies alone is an indication for their removal. It is possible to do this under local anesthetic in many instances. Quite infrequently, however, they are carried in the suprapatellar pouch for years, without trouble, and it is only when they wander down into the true joint and become caught between the joint surfaces, that they cause symptoms of any consequence. Loose bodies are occasionally seen in a Charcot joint, but are of no surgical significance.

If the bodies are multiple, and their location is a little uncertain, although anterior, the split-patella incision is the incision of choice. By this means, a thorough search of the suprapatellar pouch and anterior compartment can be made. If, however, the bodies lodge in the posterior compartment, and cannot be forced through into the anterior, the posterior internal and the posterior external incisions which I[13] have described previously are the incisions of choice, as by this means, with the knee in a flexed position, a thorough search of the posterior capsule can be made.

SUMMARY

In my experience, ruptured crucial ligaments have never been the cause of significant chronic mechanical trouble in the knee joint. Probably the ligaments unite and afford stability, or patients are able to get along without them.

The treatment of old intra-articular fractures of the knee joint is practically nil, short of arthrodesis. The patient must put up with disability and pain or accept arthrodesis. Early motion is to be encouraged.

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12. Whitelocke, R. H. A.: Loose Bodies in the Knee: Special Reference to Their Etiology and Growth, Brit. J. Surg. **1**:650-664, 1914.

13. Henderson, M. S.: Posterolateral Incision for the Removal of Loose Bodies from the Posterior Compartment of the Knee-Joint, Surg., Gynec. & Obst. **33**:698-699 (Dec.) 1921.

Recurring dislocations of the patella are more common in women, and the simple reefing operation on the inner side, with lengthening on the outer side, has been as satisfactory as any procedure.

In old fractures of the patella, the fragments must be brought together without tension, regardless of the amount of dissection necessary to bring this about. It is practical and safe to free the upper fragment and to use it as a graft to the lower.

The semilunar cartilages are most commonly the cause of mechanical derangement, and the internal is the chief offender. This is due to the fact that the internal semilunar cartilage is firmly attached to the capsule and has not the fortunate mobility that is accorded to the external; it cannot slip out of the way and it may become nipped between the condyle of the femur and the head of the tibia.

The term "loose semilunar cartilage" when applied to the internal meniscus is a misnomer. One should speak of a torn or fractured internal semilunar cartilage. The external semilunar cartilage may be spoken of as "a loose cartilage," as it is torn from its moorings and crumpled, and not necessarily fractured or torn in its substance. Repeated lockings demand the removal of the semilunar cartilages.

Osteocartilaginous loose bodies may cause mechanical derangement of a more distinct type. They occur in osteochondritis dissecans, in hypertrophic arthritis, and in osteochondromatosis. The presence of these bodies, other things being equal, is cause for their removal.

GASTROJEJUNAL ULCER: AN EXPERIMENTAL STUDY *

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Gastro-enterostomy has attained an important and standard position as a surgical procedure. Since the introduction of the anterior gastro-enterostomy by Wölfler and Billroth in 1881 and the posterior gastro-enterostomy by Von Hacker in 1885, the operation has been improved step by step. As a result of refinements in technic, the complications and sequelae of gastro-enterostomy have been steadily removed, until today it is regarded, generally, as a safe and dependable operation. However, the possibility of the occurrence of gastrojejunal ulcers following gastro-enterostomy is still a menace to the patient and is considered by Moynihan and others as the most important sequel of gastro-enterostomy.

In 1897 Braun reported the first case of jejunal ulcer following gastro-enterostomy. Quénu, in 1902, published the first case reported from France, and Mayo-Robson described the first case from England, in 1904. After the attention of surgeons was directed to this important condition, the number increased yearly. Gosset [1] was able to collect thirty-one cases in 1906. W. J. Mayo,[2] in 1910, had observed only three cases in 1,141 gastro-enterostomies; but Eusterman,[3] from the same clinic, ten years later, reported forty-seven cases in 3,700 gastro-enterostomies (1.3 per cent.) performed by them and also thirty-six cases in patients who had been operated on elsewhere. Wright [4] was able to collect 170 cases in 1917. Rowlands,[5] from a detailed review of the cases reported, believed that gastrojejunal ulcer occurred in about 1.5 per cent. of all gastro-enterostomies. Coffey [6] had 1.2 per cent. of ulcers in his series of simple gastro-enterostomies. Reports from Von Eiselberg's clinic for a period of ten years showed less than 2 per cent. of ulcers following simple gastro-enterostomy. Haberer [7] recently reported only three jejunal ulcers in 265 simple gastro-enterostomies.

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* From the surgical department of Rush Medical College.

1. Gosset: Rev. de chir. **33**:54, 1906.
2. Mayo, W. J.: Surg. Gynec. & Obst. **10**:227, 1910.
3. Eusterman, G. B.: Minnesota Med. **3**:517 (Nov.), 1920.
4. Wright, G.: Brit. J. Surg. **6**:390, 1917.
5. Rowlands: Guy's Hosp. Gaz. **27**:149, 1913.
6. Coffey, R. C.: Surg. Gynec. & Obst. **24**:350 (March) 1917.
7. Haberer: Arch. f. klin. Chir. **117**:50, 1921.

The type of operation employed has evidently had some bearing on the formation of gastrojejunal ulcer. Moynihan,[8] quoting from data compiled by Von Roogen, found, in 613 gastro-enterostomies, ten cases of gastrojejunal ulcer, of which six (3.2 per cent.) occurred following 189 anterior gastro-enterostomies and four (1.9 per cent.) following 444 posterior gastro-enterostomies. In the cases of gastrojejunal ulcer collected by Gosset, twenty followed the anterior operation and seven the posterior operation. Wright, in a series of 170 cases, found that the anterior operation had been performed in seventy-two instances and the posterior in fifty-nine. Most observers agree that these gastrojejunal ulcers are more frequent following the anterior than the posterior gastro-enterostomy. Artificial closure of the pylorus seemed to favor the occurrence of gastrojejunal ulcers. Von Eiselberg reported only four ulcers following 344 simple gastro-enterosotomies, while three cases occurred in thirty-six gastro-enterostomies in which pyloric occlusion was added to the operation. Haberer reported fourteen gastrojejunal ulcers in seventy-one cases in which the pylorus was artificially closed, as against three gastrojejunal ulcers following 265 simple gastro-enterostomies. Coffey observed but one gastrojejunal ulcer in eighty-three simple gastro-enterostomies, and two in twenty-two cases in which pyloric occlusion was used.

Gastrojejunal ulcers occur in two general types. The acute perforating form is a flabby ulcer with soft walls. There is little or no reaction in the surrounding tissues and the ulcer has a tendency to rupture into the peritoneal cavity. The chronic indurative form is a hard ulcer with a rigid wall and a definite local inflammation, with the formation of adhesions. It may perforate into the colon or some other neighboring organ, or may form a localized abscess appearing in the epigastrium.

The location of the ulcer may be on the suture line or in the jejunum near the stoma. Those ulcers on the suture line may involve the stomach or jejunum or both and should be termed gastrojejunal ulcers, as suggested by Mayo. The other group which occur in the jejunum alone may be designated as jejunal ulcers. Many of them are situated in the jejunum, directly opposite the gastro-enterostomy opening. The remainder are located within a few centimeters of the stoma, usually in the efferent loop.

The cause of the formation of these ulcers following gastro-enterostomy is still unknown. Most writers believe that the factors responsible for gastrojejunal ulcers are not the same as those which produce the jejunal type.

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8. Moynihan, B.: Brit. M. J. **2**:33 (July 12), 1919.

Gastrojejunal ulcers have generally been ascribed to errors in technic. Nonabsorbable sutures have been found embedded in these ulcers by Mayo,[9] Moynihan, Wright, Poole,[10] Hutchison,[11] Gronnerud [12] and others. They believe that the use of silk or linen sutures, which are frequently retained in the bowel wall for a long period of time, are responsible for the occurrence of these ulcers. Paterson,[13] however, does not believe that the indictment of nonabsorbable sutures is justifiable. Woolsey [14] has reported a case in which the patient had all the symptoms of a gastrojejunal ulcer. At operation a loop of silk was found dangling from the edge of the stoma; but there were no signs of an ulcer. Removal of this suture cured the patient. Marginal ulcers have been reported by Delore and Couvert [15] in cases in which catgut alone had been used. Wright found one ulcer in fourteen cases following the use of a button for intestinal anastomosis. Inaccurate coaptation of the mucous membrane is regarded as a cause by Paterson, Moynihan and Roeder.[16] Delore and Couvert,[15] however, have reported five cases of marginal ulcer following gastro-enterostomies in which they had used a three row suture, with careful approximation of the mucosa.

Bruising of the tissues by clamps is given as a cause by Moynihan [17] and Ivy.[18] Paterson [13] disagrees with this idea, as many of these ulcers have occurred in places that were not touched by the clamps. Delore and Couvert did not use clamps in the five cases referred to above; but all the ulcers in their cases were of the marginal type. Paterson and Delore and Couvert believe that the symptoms of gastrojejunal ulcer appear too long after operation to be due to the traumatism of clamps. It is well to remember, however, that many gastric and duodenal ulcers have long periods of remission during which they produce no symptoms.

Gosset [1] believed that pyloric obstruction with dilatation of the pyloric end of the stomach tended to produce these ulcers. More recently Haberer [7] and Von Eiselberg have shown that the percentage of gastrojejunal ulcers following artificial pyloric closure is many times greater

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9. Mayo, W. J.: Boston M. & S. J. **170**:149, 1914; Ann. Surg. **57**:691, 1913; ibid. **55**:398, 1912; ibid. **60**:220, 1914.

10. Poole, E. H.: Ann. Surg. **66**:122, 1917.

11. Hutchison, R.: Brit. M. J. **1**:535 (May 3) 1919.

12. Gronnerud, P.: Ann. Surg. **66**:177 (Aug.) 1917.

13. Paterson, H. J.: Internat. J. Surg. **33**:138, 1920.

14. Woolsey: Ann. Surg. **66**:121, 1917.

15. Delore and Couvert: Rev. de chir. **58**:28, 1920.

16. Roeder, C. A.: The Relation of Surgical Technic to Gastrojejunal Ulcer, Arch. Surg. **3**:622 (Nov.) 1921.

17. Moynihan, B.: Tr. Am. Surg. A. **21**: 135, 1903.

18. Ivy, A, C.: Studies on Gastric and Duodenal Ulcer, J. A. M. A. **75**: 1540 (Dec. 4) 1920.

than the percentage following gastro-enterostomy alone. Haberer believes that closing the pylorus stimulates the action of the acid producing pyloric portion of the stomach, resulting in secondary ulcer formation about the gastro-enterostomy opening. He strongly advocates performing a pylorectomy and asserts that gastrojejunal ulcers do not occur after this operation.

Hematoma formations at the time of operation, due to needle pricks, clamps or digital bruising, are mentioned as a cause by Moynihan and Mayo. Dean Lewis believes that marginal ulcers are usually due to hematomas that occur on the suture line.

Hyperchlorhydria and excessive gastric secretion are given a prominent place in the causation of secondary ulcers, especially of the jejunal type, by most observers. Paterson says that this destructive type of gastric juice may be a persistence of the kind present before operation, or it may be due to a lack of neutralization if the biliary and pancreatic juices are directed away from the stomach by operations. Bastedo [19] asserts that the neutralizing action of the bile and pancreatic fluid is not very great, as shown by observations made in a case of cholecystgastrostomy. Wilensky and Crohn have found the highest acidity when the amount of bile was greatest in the stomach. Many writers believe that the highly acid gastric juice acts as a chemical trauma to the alkaline jejunal membrane, especially in those cases in which the ulcer forms opposite the stoma. Paterson points out the fact that jejunal ulcers are more frequent following anterior gastro-enterostomy in which so often an entero-enterostomy has also been performed. He also calls attention to the fact that the gastric acidity is highest in cases of duodenal ulcer and that jejunal ulcers occur most often following gastro-enterostomies performed for the relief of duodenal rather than gastric ulcers.

The impression derived from the literature is that errors in technic are the principal causes of gastrojejunal ulcers. Hyperchlorhydria and excessive gastric secretion are thought to play a part in the production of gastrojejunal ulcers; but they are regarded as the essential cause of jejunal ulcers.

In order to obtain more definite information in regard to the cause or causes of gastrojejunal ulcers following gastro-enterostomies, a series of experiments was performed on dogs. From the literature it was found that Watts,[20] in 1903, reported two ulcers which he found in the jejunum of a dog, three months after an anterior gastro-enterostomy had been performed. He had used two rows of silk sutures and some of the silk was still dangling in the stoma; but the ulcers were not on the suture line but in the jejunum, opposite the stoma. There was no

19. Bastedo, W. A.: Am. J. M. Sc. **160**:491 (Oct.) 1920.
20. Watts: Bull. Johns Hopkins Hosp. **14**:191, 1903.

silk found in either of the ulcers. Cannon and Blake,[21] working with cats, found an occasional jejunal ulcer following gastro-enterostomy. The ulcers were located opposite the stoma or near it. Ivy[18] has reported five ulcers which he found in forty dogs that had been subjected to pylorectomy and gastroduodenostomy. In three cases the ulcers were of the acute perforating type and occurred within five weeks after operation. The ulcers in the other two cases were of the chronic variety and were found eight and eleven months, respectively, after operation. None of the ulcers were located on the suture line. All five of these dogs had vomited a great deal and had become severely emaciated. Ivy believes that the ulcers were due to cachexia from improper diet and also to the use of clamps. He says that no ulcers have occurred in dogs which he has since operated on, if he has carefully regulated their diet and used clamps merely for approximation and not for hemostasis. Gronnerud states that he has found ulcers in dogs following gastro-enterostomy but gives no particulars in regard to them. He attributes their formation to nonabsorbable sutures and the use of clamps. Borszeky[22] narrowed the pylorus and performed a gastro-enterostomy in twelve dogs. They were given 1 ounce (30 c.c.) of diluted hydrochloric acid, daily. He found a jejunal ulcer in only one of the twelve dogs.

Following out this line of work, Exalto[23] divided the duodenum at the pylorus in seven dogs, closed both ends and then performed a posterior gastro-enterostomy, using clamps and three rows of sutures. He put all seven dogs on a meat diet and gave six of them 50 c.c. of diluted hydrochloric acid, daily. None of these dogs developed an ulcer. He repeated these operations in seven other dogs; but in addition he divided the jejunum proximal to the anastomosis and closed both ends of the sectioned bowel. He then anastomosed the proximal loop to either the small or large bowel near the cecum, thus diverting the biliary and pancreatic fluid entirely away from the gastro-enterostomy. Two of the dogs were fed on a mixed diet and the other five were given a meat diet and 50 c.c. of diluted hydrochloric acid daily. Six of the dogs showed a jejunal ulcer at necropsy. One of the dogs that had been fed on meat and diluted hydrochloric acid showed no evidence of an ulcer. In four animals, the ulcers were multiple. All the ulcers were located in the jejunum opposite the stoma, except in one case in which the ulcer was located in the blind end of the jejunum.

In our experiments, gastro-enterostomies were performed on dogs by various methods, under ether anesthesia. An aseptic technic was

21. Cannon and Blake: Ann. Surg. **41**:686, 1905.
22. Borszeky: Beitr. f. klin. Chir. **57**:56, 1908.
23. Exalto: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **23**:13, 1911.

carried out in every case and clamps were used, but not for hemostasis. The pylorus was not closed in any of the operations. If the dogs did not die in the meantime, they were allowed to live several months and were then killed.

REPORT OF EXPERIMENTS

GROUP 1.—A posterior gastro-enterostomy was performed on five dogs, using a two row continuous catgut suture. In two of the dogs, before taking the final row of stitches, a hematoma was produced along the suture line by piercing a blood vessel with a needle subperitoneally, near the cardiac angle of the anastomosis. One of the three dogs without hematoma formation died on the third day after operation from a perforation along the suture line. The other two dogs died of respiratory infection, twenty-two and forty-seven days after operation. There was no ulcer found in either of these animals at necropsy. Of the two dogs in which a hematoma had been produced at operation, one died of a respiratory infection twenty-six days after operation. At necropsy a very definite ulcer was found in the jejunum, bordering on the suture line (Fig. 1), at the cardiac angle of the stoma. The ulcer was of the chronic indurative type, 6 by 15 mm. in size, and occupied the position of the hematoma made at the time of operation. The anastomosis otherwise was perfectly healed and there were no adhesions. The other dog died of peritonitis, 185 days after operation. At necropsy, a perforated ulcer was found in the jejunum, bordering on the stoma at the cardiac angle of the anastomosis where the hematoma had been located (Fig. 2). The ulcer was 8 by 10 mm. in diameter, and had a hard, thin edge.

GROUP 2.—Five dogs were subjected to a posterior gastro-enterostomy, using three rows of continuous catgut suture. Hematomas were made at the pyloric angle of the anastomosis in two of the dogs by the method described above. The animals operated on without hematoma formation died of respiratory infections, eleven, twelve and eighteen days, respectively, after operation. The anastomosis was found to be intact and patent in every case at necropsy. The peritoneal cavity was clean. The edge of the stoma was healed, except at the angles where healing was not yet complete. There was no ulcer in any of these dogs. Of the two animals in which a hematoma had been made at operation, one died of distemper, ninety days after operation. The other animal was killed in a dog fight, twenty-two days after operation. Necropsy in both cases revealed perfect healing of the anastomosis. The places where the hematomas had been made appeared entirely normal. There was no evidence of an ulcer in the stomach or jejunum of either of these dogs.

GROUP 3.—Five dogs were subjected to a posterior gastro-enterostomy by the two row suture method. Continuous catgut was used for the inner row and continuous silk for the outer row. In two of the dogs a hematoma was made by the method already described, about midway between the angles of the anastomosis, in one case on the jejunum and in the other on the stomach. These hematomas were inoculated with 1 c.c. of a suspension in salt solution of virulent colon bacilli. Of the three animals operated on, without hematoma formation, one died thirty-one days after operation. At necropsy a large hair ball was found blocking the outlet of the stomach. The anastomosis was perfectly healed, with no signs of ulcer formation. The other two dogs died of skin diseases, 138 and 158 days, respectively, after operation. The anastomosis

was well healed at necropsy, although silk threads were dangling from the margins of the stoma, especially at the angles, in both cases. In neither animal was there any sign of an ulcer formation. The two animals with hematomas, which had been inoculated with colon bacilli at the time of operation, were killed, 139 and 137 days, respectively, after operation. A necropsy in both cases demonstrated that the anastomosis was healed but that silk was dangling in the bowel from the margin of the stoma. The hematoma had disappeared without leaving any perceptible scar. There were no ulcers.

Group 4.—This consisted of five dogs in which the experiment described above was repeated, except that a three row suture was employed in the anastomosis instead of a two row suture. Continuous catgut was used for the two inner rows and continuous silk for the outer row.

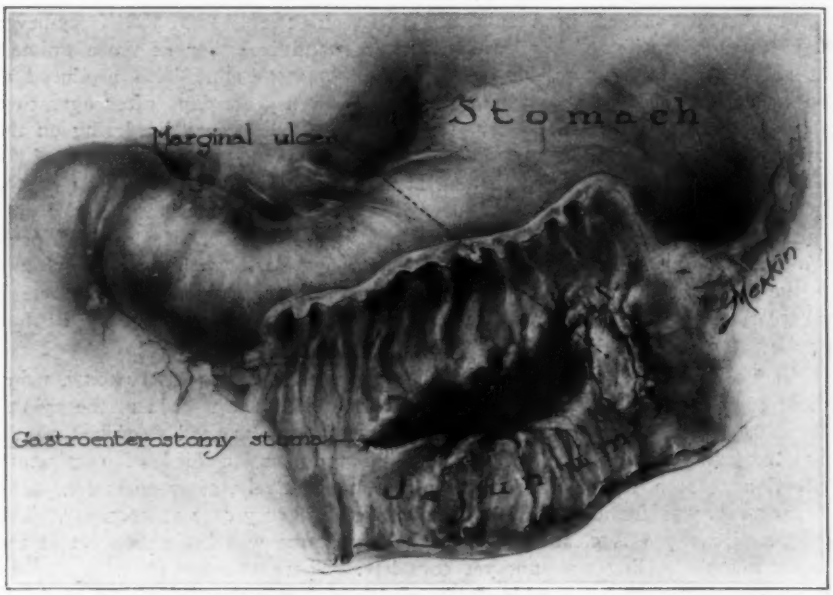

Fig. 1.—Gastrojejunal ulcer in a dog, twenty-six days after operation.

Of the three dogs operated on without hematoma formation, two died of distemper 146 and 221 days, respectively, after operation. The third animal died thirty-three days after operation, probably from a hair ball in the stomach. Necropsy in these three dogs was negative in regard to ulcer formation. The anastomoses were well healed. Silk was dangling from a margin of the stoma in the dogs that lived 146 and 221 days, respectively, after operation. Hematomas were made in the other two dogs in this group; they were also inoculated, just as in Group 3. One of these dogs died from an infection of the abdominal wound, nine days after operation. At necropsy there were omental adhesions about the site of the hematoma on the jejunum. The mucosa appeared to be healthy everywhere, and healing of the anastomosis had progressed normally. The other animal died from a respiratory infection, 123 days after operation. The anastomosis was well healed, with no evidence remaining of the hematoma. The silk suture had eroded into the bowel in several places but there was no ulcer formation.

GROUP 5.—This comprised eight dogs that were subjected to a posterior gastro-enterostomy, using the two row suture method. Continuous catgut was employed for the inner row and interrupted silk for the outer row. In addition, a hematoma was made in four of the animals by the subserous needle puncture of the vessels. The hematoma in two of the dogs was placed at the cardiac angle, in one on the stomach and in the other on the jejunal side. In the other two dogs, the hematoma was made at the pyloric angle, in one on the stomach and in the other on the jejunal side. Of the four dogs operated on without hematoma formations, one died from an infection of the abdominal wall, four days after operation. The abdominal cavity was clean at necropsy and the anastomosis was intact. There was no sign of an ulcer. Another dog died of a respiratory infection, forty-one days after operation. The anastomosis was well healed. Silk was present in the jejunum in two places;

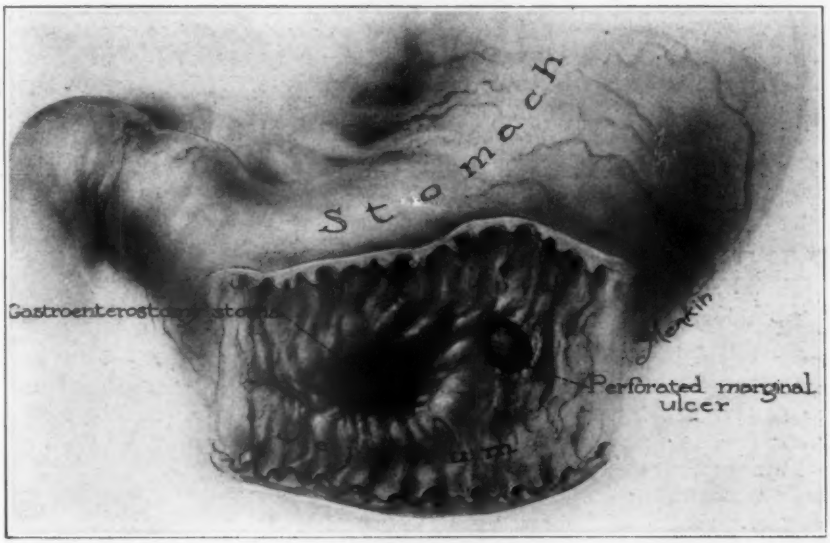

Fig. 2.—Perforated gastrojejunal ulcer in a dog, followed by death from peritonitis, 185 days after operation.

but there was no evidence of ulcer formation. A third dog died of respiratory infection, forty-six days after operation. The anastomosis appeared to be perfectly healed. There was no ulcer present, although a silk suture was present in the jejunum in one place. The fourth dog was killed, 270 days after operation. The anastomosis was perfectly healed. There was no silk showing on the mucosa, and there was no sign of an ulcer.

Of the four dogs operated on with hematoma formation, one died of respiratory infection, 125 days after operation. The anastomosis was well healed. There was no silk showing on the mucosa. The hematoma had entirely disappeared and there was no sign of an ulcer. Another dog was killed, eighty-nine days after operation. The anastomosis was well healed. Silk had eroded into the jejunum in three places. The hematoma had disappeared and there was no sign of an ulcer. A third dog died of distemper, eighteen days after operation. The anastomosis was almost healed and no silk showed on the mucosa. At the site of the hematoma which had been made on the

stomach at the cardiac angle, there was a small area of submucous hemorrhage, with some erosion of the mucosa but no definite ulcer formation. The fourth dog died of a skin disease, 200 days after operation. The anastomosis was thoroughly healed. At the site of the hematoma on the jejunum at the cardiac angle of the stoma, there was a marginal ulcer 7 by 15 mm. in size (Fig. 3). The edge of the ulcer was round, elevated and well defined. The base was clean and did not show any silk.

Group 6.—This consisted of thirteen dogs that were subjected to a posterior gastro-enterostomy. The anastomosis was made with two rows of continuous silk sutures. In five of the animals, the outer suture row when completed was tied and the ends of the suture cut off about an inch (2.5 cm.) beyond this and tied into a knot. The loop of two silk threads, an inch (2.5 cm.)

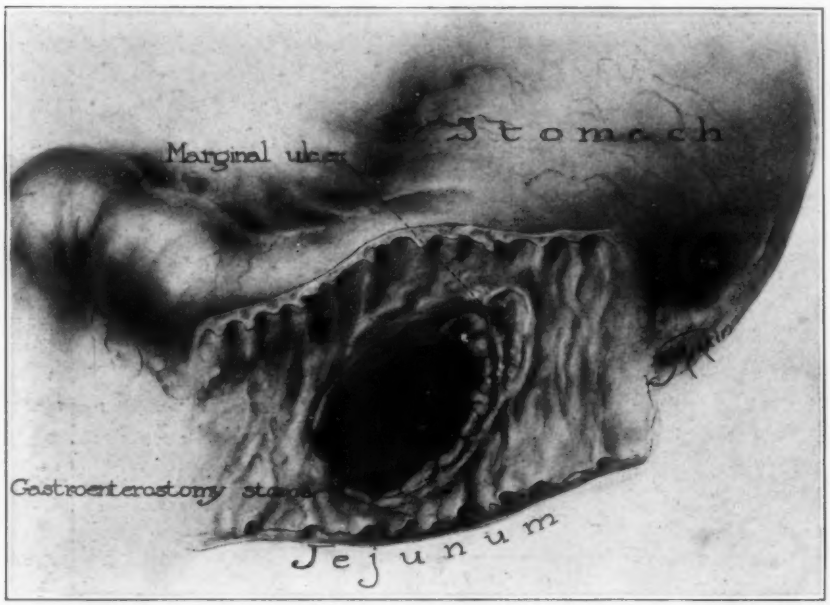

Fig. 3.—Gastrojejunal ulcer in a dog, 200 days after operation.

long with a knot at the end, was pushed into the bowel between the edges of the anastomosis and allowed to dangle in the lumen. Of these five dogs, two died of respiratory infection twenty-two and thirty-one days, respectively, after operation; two died of skin disease, twenty-six and thirty-seven days, respectively, after operation, and one died of a large hair ball in the stomach, forty-six days after operation. The anastomosis was healed in all five animals, except at one or more places where the inner thread was still adherent, although the greater part of the suture was hanging free in the bowel. The knotted end of the outer suture that had been pushed into the bowel was dangling there. In two instances, the knot had been made much larger by hair that had collected on it. Two of the dogs had had tarry stools, and old blood was present in the jejunum near the stoma. There was no evidence of ulcer formation in any of the five animals. Of the other eight dogs in this group, three died of respiratory infection, ten, seven and seventeen days, respectively, after operation. The anastomoses appeared to be healing normally,

and there were no signs of ulcer formation. One dog was killed in a fight, eighteen days after operation. The specimen was too badly mutilated to be of any value. Another dog died of evisceration, as a result of an infected abdominal wound, fifty-three days after operation. The anastomosis was healed in this animal except at one place where the inner suture thread was still adherent. There was no ulcer present. Another dog died of distemper, 127 days after operation, and the remaining two dogs died of chronic skin diseases, 154 and 208 days, respectively, after operation. In the last three animals, the anastomoses were found to be well healed. The inner suture thread had entirely disappeared; but the outer suture row had eroded into the bowel in one or more places. There was no evidence of ulcer formation in any of these dogs.

Fig. 4.—Gastrojejunal ulcer in a dog, 100 days after operation.

GROUP 7.—This comprised five dogs that were subjected to an anterior gastro-enterostomy, using two rows of continuous catgut sutures. In two of the dogs a hematoma was made in the jejunum near the suture line, at the pyloric angle in one animal, and at the cardiac angle in the other. One dog died of pneumonia, four days after operation; another escaped from the laboratory, thirty-seven days after operation; a third was killed, 122 days after operation. Of the two dogs with hematoma formation, one died of a respiratory infection, twenty-six days after operation, and the other was killed ninety days after operation. In the four animals on which we were able to perform a necropsy, healing of the anastomosis was complete or was progressing normally. The hematoma had disappeared and there was no ulcer present.

GROUP 8.—This consisted of five dogs that were subjected to an anterior gastro-enterostomy, using three rows of continuous catgut sutures. In two of the dogs, hematomas were made as in the preceding experiment. One dog

died of pneumonia, nine days after operation; another died of distemper, sixteen days after operation, and the third was killed, 120 days after operation. The two dogs in which a hematoma had been made died of respiratory infection, twenty-four and thirty-six days, respectively, after operation. In these five dogs, healing of the anastomosis was either complete or progressing normally. The hematomas had disappeared and there was no ulcer formation.

Group 9.—In this group there were five dogs that were subjected to a gastro-enterostomy and an entero-enterostomy of the afferent and efferent loops. A two row continuous catgut suture was used in making both anastomoses.

Results of Experimental Study of Gastrojejunal Ulcer

Group	Operation	Suture Material	Hematoma	Ulcer	Without Hematoma	Ulcer
1 5 dogs	Posterior gastro-enterostomy, two row suture	Continuous catgut; both rows	2	2	3	0
2 5 dogs	Posterior gastro-enterostomy, three row suture	Continuous catgut; three rows	2	0	3	0
3 5 dogs	Posterior gastro-enterostomy, two row suture	Continuous catgut, inner row; continuous silk, outer row	2 Inoculated	0	3	0
4 5 dogs	Posterior gastro-enterostomy, three row suture	Continuous catgut, inner two rows; continuous silk, outer row	2 Inoculated	0	3	0
5 8 dogs	Posterior gastro-enterostomy, two row suture	Continuous catgut, inner row; interrupted silk, outer row	4	1	4	0
6 13 dogs	Posterior gastro-enterostomy, two row suture; five with knot in bowel	Continuous silk, both rows	0	0	13	0
7 5 dogs	Anterior gastro-enterostomy, two row suture	Continuous catgut, both rows	2	0	3	0
8 5 dogs	Anterior gastro-enterostomy, three row suture	Continuous catgut, three rows	2	0	3	0
9 5 dogs	Anterior gastro-enterostomy with entero-enterostomy, two row suture	Continuous catgut, both rows	0	0	5	1
10 7 dogs	Anterior gastro-enterostomy with entero-enterostomy, two row suture	Continuous silk, both rows	0	0	7	0

One dog died of hemorrhage the day after operation. Another dog died of pneumonia, three days after operation. A third dog died from an unknown cause, eighty-six days after operation. A necropsy on this animal revealed the fact that both anastomoses were perfectly healed, with no signs of an ulcer in the stomach or bowel. The fourth dog developed skin trouble and died from infection produced by scratching, 104 days after operation. A necropsy on this animal disclosed perfect healing of both anastomoses and no evidence of ulcer formation. The fifth dog lived 100 days after operation. A very large hair ball was found in the stomach of this animal after death.

Bordering on the stoma at the cardiac angle, there was a definite hard ulcer, 7 by 7 mm. in diameter, lying between the rugae on the gastric mucosa (Fig. 4).

GROUP 10.—This consisted of seven dogs that were subjected to an anterior gastro-enterostomy with an entero-enterostomy, as in the previous experiment. A two row continuous silk suture was used instead of catgut in making the anastomoses. One dog died of pneumona, six days after operation. The anastomosis at necropsy appeared to be healing normally. Another dog died of exposure to cold the day after operation. A third dog probably died because of a bundle of worms that blocked the stoma. He was found dead, thirty-six days after operation. A fourth animal died of distemper, ninety-eight days after operation. The fifth and sixth dogs were killed, sixty-one and 121 days, respectively, after operation. A seventh dog died of peritonitis, forty-one days after operation. In the last five dogs, necropsy demonstrated that the anastomoses were well healed, except at two or three places about each stoma, where the inner thread was still attached. The outer thread had ulcerated into the bowel at several places, especially at the cardiac angle where the knot was located. There was no evidence of definite ulcer formation in the stomach or bowel of any of these animals.

COMMENT

In this series of experiments, sixty-three dogs were subjected to a gastro-enterostomy. Of this total number, one escaped from observation, the thirty-seventh day after operation; another died of hemorrhage, the second day after operation, and a third died, the day after operation, from exposure to cold These three animals may be omitted from our calculations, leaving sixty dogs to be considered in our observations. A definite gastrojejunal ulcer was found in four (6.66 per cent.) of these sixty animals. In every case the ulcer was a fairly large, solitary lesion, somewhat indurated and well defined. Macroscopically, it showed all the characteristics of a chronic ulcer. This diagnosis was confirmed by microscopic sections, which showed a definite ulcer border with erosion of the mucosa and muscularis mucosa. In the submucosa which formed the floor of the ulcer, there was definite round-cell infiltration.

After reviewing our work, certain factors were considered in relation to their influence on the production of these marginal ulcers.

Some years ago, Cannon and Blake [21] pointed out that the anterior gastro-enterostomy in animals like the dog or cat was the nearest approach to the posterior operation in man. In view of that fact, our results correspond to numerous observations in man in which gastrojejunal ulcers have been found much more frequently following the anterior than the posterior operation. Three of the ulcers in our series occurred after posterior gastro-enterostomy and only one after an anterior gastro-enterostomy. In this one instance, the ulcer was located on the gastric mucosa bordering on the stoma. It was the only one of

the four ulcers that formed on the stomach side of the opening. At necropsy on this animal, a very large hair ball was found occluding the pylorus and the gastro-enterostomy stoma. It is very probable that the hair ball, impregnated with dirt and fragments of bone, was the cause of the ulcer.

Diverting the flow of bile and pancreatic secretion from the stomach by means of an entero-enterostomy did not seem to have any definite effect on ulcer production. Only one dog in which we employed this procedure developed an ulcer. That particular ulcer is the one that was probably due to the grinding action of the hair ball, as has just been stated. Diverting the alkaline secretion would seem to have been a minor factor at the most.

Hematoma formation appeared to have exerted a marked influence in the production of these ulcers. In three dogs, an ulcer formed at the site of a hematoma which had been placed on the jejunal border of the stoma. In no instance did an ulcer form at the position of a hematoma placed on the gastric side of the stoma. From this observation, it would seem that the gastric mucosa was more resistant to the devitalizing action of a hematoma than the jejunal mucosa. In those cases in which an ulcer did not form at the site of the hematoma, healing progressed normally and the hematoma was absorbed. Inoculating the hematomas with virulent colon bacilli produced only negative results. In every case in which the inoculation was performed, the wound progressed to normal healing without ulcer formation. The dogs evidently had a strong resistance to colon bacilli. In connection with this question of hematomas, it is interesting to note that all of the ulcers occurred in cases in which the two row suture method had been used, although hematomas were made in an equal number of dogs operated on by the three row method. It would seem logical to believe that the middle row of sutures prevented the hematoma from extending to the mucosa. In addition, as Roeder has recently shown, the three row suture method provides better hemostasis and more careful apposition of the mucous edges. It tends to early healing by avoiding the strangulation and subsequent sloughing of the mucosa that occur when a mattress stitch, embracing all the coats, is used to control bleeding. Roeder shows that the scar after the three row suture is much smaller and softer.

Another interesting observation was that all four of our ulcers were located at the cardiac angle of the anastomoses. This corresponds to the clinical findings of a number of surgeons in regard to these marginal ulcers in man. The cardiac angle is usually the place where the last stitches are taken in performing a gastro-enterostomy and where the knots are placed. With a two row suture, it is frequently very difficult

to secure good apposition at this point, and a poorly placed suture permits gaping of the mucous edges and hematoma formation. In addition, the cardiac angle is the place that sustains the greatest strain from the long dependent efferent loop, so that healing at this point is most liable to be delayed on account of interference with the blood supply. The three row suture method permits good suturing at this angle where it would seem to be especially needed.

Nonabsorbable suture material has been very generally blamed by surgeons for producing marginal ulcers. According to Rogers, Senn showed experimentally that all nonabsorbable suture material used in performing a gastro-enterostomy ultimately sloughed into the bowel. This was observed in our animals in which silk from one or both rows was found eroding into the bowel or dangling from the edge of the stoma, months after the operation. Despite this fact, all of our ulcers except one occurred in animals in which only catgut had been used. In that one case, an ulcer occurred where catgut had been used for the inner row and interrupted silk for the outer row. At necropsy the interrupted silk sutures seemed to have disappeared entirely in the 200 days that had intervened after operation. There was no silk embedded in the base or edge of the ulcer. These results in animals would seem to agree with those of a number of observers who have found gastrojejunal ulcers in man when catgut alone had been used. Our experiments fail to show any causal relationship between nonabsorbable suture material and gastrojejunal ulcers. However, they emphasize the fact that nonabsorbable sutures ultimately slough out, but the process often extends over months. Interrupted silk sutures used in our animals sloughed out much more rapidly than the continuous silk sutures. Dangling knots, even when enlarged by hair which became entangled, did not produce an ulcer in any instance.

Clamps were used to approximate the stomach and jejunum in every anastomosis. As the ulcers we obtained occurred on the edge of the stoma and not on the line of application of the clamps, it is impossible to believe that clamps had any influence on our results.

The effect of pyloric occlusion on the formation of gastrojejunal ulcers has not been considered in this report, as the pylorus was allowed to remain patent in every case. This factor will be dealt with in a subsequent paper.

CONCLUSIONS

From this series of experiments on dogs, these conclusions have been drawn:

1. Gastrojejunal ulcers occur in dogs following gastro-enterostomy with a patent pylorus.

2. These ulcers have a tendency to perforate and are similar in other respects to gastrojejunal ulcers found in man.

3. They seem to occur following hematomas that affect the jejunal mucous membrane at the cardiac angle of the stoma where suturing and hemostasis are imperfect.

4. The imperfections in technic at this place may be avoided by the use of the three row suture method.

5. Hematomas situated at other places along the suture line may be absorbed and produce no damage.

6. Gastrojejunal ulcers occur independent of the kind of suture material employed.

7. Gastrojejunal ulcer in dogs is more frequent following the posterior operation, which corresponds to the anterior operation in man.

122 South Michigan Avenue.

MESENTERIC VASCULAR OCCLUSION *

LEO BRADY, M.D.

BALTIMORE

Reports of cases of mesenteric thrombosis and embolism treated successfully by surgical intervention no longer receive the widespread comment that in 1895 greeted Elliot's article on the first instance of recovery of a patient with intestinal infarction. However, even today the mortality in these cases is very high, and reports of surgical successes are still of considerable interest.

The first instance of occlusion of the mesenteric vessels seems to have been reported by Tiedemann [1] in 1843, and four years later Virchow [2] explained the pathology of the condition. In 1875 Litten described fairly accurately the clinical picture. From that time until 1895, when Elliot [3] reported his famous case, there were no great advances made in the diagnosis or treatment of this condition. Jackson, Porter and Quinby,[4] in 1904, published what was probably the most complete study made on this subject up to that time. Trotter,[5] in 1913, reported six new cases and analyzed the 360 reports of cases already in the literature. The only one of his six patients that recovered did so without operation, which, of course, makes the accuracy of the diagnosis doubtful. Ross,[6] in 1920, reported six new cases with one operative success. Although in the case reported by Ross of the patient that recovered, thrombosis of a branch of the superior mesenteric artery was noted at operation and there was some hemorrhage into the mesentery; the segment of bowel involved was in fairly good condition and no resection was performed. This was undoubtedly one of the rare instances of sufficient collateral circulation developing after a mesenteric thrombosis to prevent the formation of an intestinal infarction. The last article on this subject appeared in July, 1921, consisting of

* From the Gynecological Department of the Johns Hopkins Hospital and the Johns Hopkins University Medical Department.

1. Tiedemann: Von d. Verengerung u. Schliessung d. Pulsadern in Krankheiten, Heidelberg and Leipzig **131**:1843.

2. Virchow: Gesamte Abhandlungen, pp. 338, 420, 451.

3. Elliot, J. W.: The Operative Relief of Gangrene of the Intestine Due to Occlusion of the Mesenteric Vessels, Ann. Surg. **21**:1895.

4. Jackson, J. M.; Porter C. H., and Quinby, W. C.: Mesenteric Embolism and Thrombosis, J. A. M. A. **42**:1469 (June 4), 1904; ibid. **43**:25 (July 2), 110 (July 9), 183 (July 16), 1904.

5. Trotter, L. B. C.: Embolism and Thrombosis of the Mesenteric Vessels, Cambridge University Press, 1914.

6. Ross, G. G.: Mesenteric Thrombosis, Ann. Surg. **72**:121 (July), 1920.

a report by Loop [7] of nine cases in which operation was performed. Eighteen inches (45.7 cm.) of intestine was removed and a lateral anastomosis was performed on the one patient in this series that survived. At the present time there are records in the literature of about 500 cases of mesenteric thrombosis and embolism with not more than thirty-five recoveries. Of the forty-seven patients operated on in Jackson's series only four survived.

Recently I treated a patient with intestinal infarction that survived. My interest in this subject being aroused I decided to go over the records in the Johns Hopkins Hospital of all the patients with mesenteric thrombosis and embolism. In all I found fourteen instances of mesenteric vascular occlusion. However, in three cases there was no formation of an intestinal infarction and the mesenteric thrombosis was discovered only at necropsy. That in a slowly developing thrombosis of the mesenteric vessels the collateral circulation may develop sufficiently rapidly to prevent the formation of an infarction has long been known. To quote from Welch's [8] article in Allbutt's System of Medicine: "Intestinal infarction is not the imperative result of occlusion of the superior mesenteric artery as infarction is of occlusion of branches of the splenic and renal arteries." Welch quotes Chiene's [9] case of a woman, 65 years old, with an aneurysm of the abdominal aorta and complete obliteration of the celiac axis and both mesenteric arteries, who had an adequate collateral circulation through the greatly distended extraperitoneal anastomosing arteries. But Welch says later, "The rapid and complete closure of the superior mesenteric artery, however, is followed with great regularity, probably constantly, by hemorrhagic infarction of the intestine."

REPORT OF CASES OF MESENTERIC VASCULAR OCCLUSION IN WHICH NO INTESTINAL CHANGES DEVELOPED

CASE 1.—*History.*—J. J., man, aged 80, white, admitted, Jan. 4, 1909, had had an attack of shortness of breath one year previously. The second attack occurred two weeks before admission. Both of these attacks lasted only a few minutes. Otherwise the patient's past history was negative. Digestion had always been good and the bowels had moved regularly. There were no urologic symptoms before the present illness, and no history of gonorrhea or syphilis. For the last three years the patient had been growing gradually weaker. One week before admission, he began to have difficulty in voiding, and during the week this difficulty increased. The patient had to be catheterized several times by his family physician.

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7. Loop, R. G.: Mesenteric Vascular Occlusion, J. A. M. A. **77**:369 (July 30), 1921.

8. Welch, W. H., in Allbutt: System of Medicine **7**, 1899.

9. Chiene: J. Anat. & Physiol. **3**:65-107, 1869.

Physical Examination.—The patient was poorly nourished. Nothing abnormal was detected in the heart and lungs. The abdominal examination was entirely negative. Through the rectum a greatly enlarged prostate could be felt. The urine showed many pus cells.

Course in Hospital.—The patient's condition became gradually worse, and on the seventeenth day in the hospital he died (January 21). Nothing abnormal was ever demonstrated in the patient's abdomen.

Necropsy.—The anatomic diagnosis was: "Prostatic enlargement; hemorrhagic cystitis; ureteritis and pyelonephritis; chronic fibrous myocarditis with thrombus formation; arteriosclerosis of the aorta with ulceration; mural thrombosis of the iliac artery; thrombosis with occlusion of the superior mesenteric artery; anastomotic circulation." The intestines remained normal because of the extensive anastomotic circulation, although the superior mesenteric artery was completely obstructed near its origin by a dense thrombotic mass.

CASE 2.—*History.*—G. I., man, aged 45, white, admitted May 13, 1915, gave an essentially negative history, with no mention of any dyspnea on exertion or swelling of the ankles. There had been no gastro-intestinal disturbances until the present illness. Six months before admission to the hospital, the patient began to complain of belching and constipation. During the last three months he had noticed that he was becoming more and more jaundiced and that his stools were white.

Physical Examination.—The patient was very much emaciated and quite jaundiced. The temperature on admission was 99.6 F.; the pulse, 100; respirations, 20. The liver could be felt three finger-breadths below the costal margin, but no abdominal tenderness was present. The patient's stools were clay-colored.

Course in Hospital.—On the tenth day in the hospital the patient began for the first time to complain of abdominal pain and to vomit. His temperature rose to 104 F. An operation was immediately performed by Dr. McClure. A large amount of yellowish fluid was found in the peritoneum. There was a hole in the common duct. The gallbladder was drained, and several drains were placed in the peritoneal cavity. The patient died that evening.

Necropsy.—The anatomic diagnosis was: "Carcinoma of the head of the pancreas with metastases to the liver and neighboring lymph glands; obstruction of common duct; jaundice; thrombosis of the superior mesenteric artery. The intestines appeared normal, except for a few minute hemorrhages."

CASE 3.—*History.*—C. D., man, aged 51, colored, was admitted Oct. 3, 1919, with an entirely negative past history and with no history of any cardiovascular trouble. The present illness was limited to the condition for which the patient was operated on, double inguinal hernia. The patient had had the hernias for many years.

Course in Hospital.—An operation was performed Oct. 14, 1919, for double hernia (Dr. Reid). At the tip of the large hernial sac on the right, there was an abscess. Several loops of intestine were adherent to the abscess sac. A low right rectus incision was made and the abscess wall, with the loops of intestine still adherent, was sutured to the abdominal wall. Four days later the abscess was opened. The patient's temperature never returned to normal after the abscess had been opened, and the course was gradually downward. November 17, the patient died.

Necropsy.—The anatomic diagnosis was: "Old inguinal hernia with strangulation and abscess formation; thrombosis of the inferior mesenteric vein; septic thrombosis of the main portal vein." The intestines were perfectly normal.

COMMENT

Case 3 is the only instance in our series of thrombosis of the inferior mesenteric vessels. Other observers have also noted the relative infrequency of thrombosis of the inferior mesenteric vein as compared with its occurrence in the superior mesenteric vessels. Before leaving this case of associated portal and mesenteric thrombosis, it might be well to quote again from Welch's article: "Of interest is the relation of thrombosis of the mesenteric veins to portal thrombosis. In several instances of the latter, thrombosis of the mesenteric veins occurred without hemorrhagic infarction of the intestine. Doubtless, the explanation is that a sufficient collateral circulation had been established after the portal thrombosis to prevent the usual effects of a subsequent mesenteric thrombosis. That this, however, is not always the case is shown by the sudden or more gradual termination in some instances of portal thrombosis with hemorrhagic infarction of the intestine in consequence of the extension of the thrombus into the mesenteric veins."

REPORT OF CASES OF MESENTERIC VASCULAR OCCLUSION CAUSING INTESTINAL INFARCTION WHICH WERE NOT TREATED SURGICALLY

Case 4.—*History.*—H. H., man, aged 49, white, admitted, April 2, 1895, had been in the hospital three times previous to his last admission. A diagnosis of cirrhosis of the liver and diabetes mellitus was made on the first admission and was confirmed on all subsequent admissions. Four days before entering the hospital for the last time, the patient developed severe pain in the lower abdomen. The abdominal pain persisted during these four days, but at no time was there any vomiting.

Physical Examination.—The patient looked very ill. The temperature was 100 F., the pulse, 110, and respirations, 20. The abdomen was markedly distended and general abdominal tenderness was present. The urine showed 2.5 per cent. sugar.

Course in Hospital.—The patient's course was rapidly downward, and he died on the second day, April 4. Just before death his temperature rose to 102 F.

Necropsy.—The anatomic diagnosis was: "Diabetes mellitus, cirrhosis of the liver; thrombosis of the portal and superior mesenteric veins; hemorrhagic infarction of the intestine."

Comment.—This case is probably an example of (to quote again from Dr. Welch) "sudden or more gradual termination of portal thrombosis with hemorrhagic infarction of the intestine in consequence of the extension of the thrombus into the mesenteric veins." This patient had abdominal tenderness and distention; but as he was known to have diabetes mellitus and cirrhosis of the liver, the abdominal signs were attributed to those conditions. An acute condition of the abdomen demanding surgical intervention was not suspected and an operation was not considered.

Case 5.—*History.*—D. B., man, aged 52, colored, admitted, Oct. 13, 1898, had been admitted to the hospital on four previous occasions. The diagnosis

on all these was aortic insufficiency, arteriosclerosis and mitral stenosis. On each admission, the patient's heart was found decompensated; but following rest and therapy, he was able to go back to work.

Present Illness.—The patient was readmitted to the hospital, Oct. 13, 1898, for another cardiac breakdown. On admission he had no abdominal symptoms and the abdomen was negative on examination. Six days after admission, the patient suddenly began to complain of pain in the lower abdomen, and the abdomen became almost instantly rigid and immobile. The temperature rose to 101 F., the pulse to 110. The patient died the following day, October 30. There was no vomiting at any time.

Necropsy.—The anatomic diagnosis was: "Arteriosclerosis; sclerosis of the aortic valve; thrombosis of the left ventricle; thrombosis of the superior mesenteric artery; hemorrhagic infarction of the intestine; acute peritonitis."

As the abdominal findings were rather characteristic of those found in cases of thrombosis of the main branch of the superior mesenteric artery with infarction of all the intestine supplied by that vessel, I shall quote in some detail the description of Dr. Simon Flexner who performed the necropsy:

"The peritoneal cavity contains several hundred cubic centimeters of thin sanguineopurulent fluid. The loops of intestine are much distended. They present a deep purplish color. The loops which are especially distended and hemorrhagic are those of the small intestine; the upper part of the large intestine is also involved. The superior mesenteric artery is thickened; its intima contains sclerotic and fatty patches, but there are no ulcers. Its lumen is completely filled with a moderately firm red thrombus, which is lightly adherent to the vessel walls. The length of the thrombus is about 3 cm. On closer inspection it is proved that the infarcted area extends so as to involve the duodenum, the jejunum and ileum throughout their entire lengths and the cecum and ascending portions of the colon. The transverse colon is involved in a part of its extent only. The content of the intestine is a fluid of serosanguineous composition. The mucous membrane of the small intestine is deeply suffused with blood, also that of the cecum and ascending colon."

While the presence of an acute abdominal condition was recognized in this case, an operation was not considered, as the patient's heart at the onset of the intestinal symptoms was markedly decompensated.

Case 6.—*History.*—B. S., woman, aged 60, white, admitted, March 24, 1919, gave an entirely negative past history. The patient had always had good health until the onset of the present illness. Three weeks before admission, the patient developed shortness of breath and edema of the ankles. At the same time the abdomen began to swell; but there was no abdominal pain or vomiting at that time.

Physical Examination.—The patient was somewhat cyanotic. The temperature was 97 F.; the pulse, 110; respiration, 24; leukocyte count, 6,000. The pulse showed that the auricle was fibrillating. The abdomen was moderately distended and filled with fluid but was not tender. A diagnosis of cirrhosis of the liver, myocardial insufficiency and auricular fibrillation was made.

Course in Hospital.—On the fifth day after admission, the patient developed severe abdominal pain and died on the following day, March 30. She vomited several times during the last two days. The leukocyte count rose from 6,000 to 24,000; but the temperature remained subnormal throughout.

Necropsy.—The anatomic diagnosis was: "General arteriosclerosis; fibrous myocarditis; cirrhosis of the liver; thrombosis of the superior mesenteric veins;

hemorrhagic infarction of the jejunum with hemorrhage into the stomach, duodenum, jejunum and ileum."

COMMENT

While it is true that at necropsy we might possibly say that surgical interference was indicated in these cases, still it was not possible during life to say more than that these patients had an acute abdominal condition. The cases of mesenteric vascular occlusion that are diagnosed as such are as rare as are the patients that recover from that condition. Moreover, two of these patients had decompensated hearts when the abdominal symptoms commenced, and the third had diabetes mellitus and cirrhosis of the liver, so the hope that laparotomy offered to these patients was almost negligible.

REPORT OF CASES OF MESENTERIC VASCULAR OCCLUSION TREATED SURGICALLY

CASE 7.—*History.*—C. C., man, aged 52 years, white, admitted, Sept. 15, 1898, with an essentially negative past history, for three weeks had had some pain in the abdomen and occasional attacks of vomiting. Five days before admission to the hospital, the abdominal pain had become more severe and the vomiting had occurred more frequently.

Physical Examination.—The temperature was 100 F.; pulse, 72; respirations, 24. The patient appeared quite ill. The abdomen was moderately distended and definite muscle spasm was present.

Operation (Dr. Bloodgood).—"On opening the peritoneal cavity it was seen to contain a considerable amount of bloody fluid with no fecal odor. There was a mass present, which consisted of several coils of small intestine. The intestine appeared somewhat gangrenous and was quite dark in color. The mesentery below the intestine was also definitely engorged and blackened and the vessels of the mesentery seemed thrombosed. The gangrenous intestine was brought out of the abdomen but not resected. An enterostomy was done." The patient died on the second day after the operation, September 18.

Necropsy.—The anatomic diagnosis was: "Thrombosis of the mesenteric veins; necrosis and gangrene of the small intestine; general fibrinopurulent peritonitis." The mesenteric artery was free. The heart and aorta were normal.

CASE 8.—*History.*—G. W., woman, aged 45, white, was so ill when admitted to the hospital, July 14, 1900, that no past history could be obtained. Severe abdominal pain had started five days before admission. The pain had been especially severe a little to the left of the umbilicus. Vomiting had occurred frequently.

Physical Examination.—The temperature was 100.2 F.; the pulse, 140; respirations, 28; leukocyte count, 20,000. The history says, "Patient looks very ill. Abdomen is markedly distended and very tender on palpation. Considerable muscle spasm is present."

Operation (Dr. Mitchell).—"On opening the peritoneal cavity it was found to contain a great quantity of thin dark-brown fluid. A loop of distended blue-black small intestine was seen running transversely above the umbilicus and down the right side of the abdomen. There was a definite thrombus in the branch of the superior mesenteric artery supplying the discolored intestine. The gangrenous intestine was excised, some good intestine being removed at either

end in an attempt to take care of any extension of the thrombosis. The two ends of the intestine were brought out through the abdominal incision." The patient died on the following day, July 20. Permission for a necropsy could not be obtained.

CASE 9.—*History.*—J. S., man, aged 48, colored, admitted June 10, 1906, with an essentially negative past history, was admitted, June 9, 1906, on the medical service because of a severe cold he had had for two weeks. During the first day on the medical service, he vomited once. The next day vomiting occurred frequently and severe abdominal pain began. The temperature rose to 103 F. and the leukocyte count to 13,000. The patient was at once transferred to the surgical service.

Physical Examination.—When admitted on the surgical service, the patient was irrational. The abdomen was considerably distended and shifting dulness could be demonstrated in the flanks.

Operation (Dr. Sowers).—"On opening the peritoneal cavity, a small amount of turbid fluid with a foul odor poured out. Numerous loops of gangrenous intestine were seen. These loops were distended and quite black. Fifty-two inches of intestine was removed and the divided ends of the intestine brought out through the wound." The patient lived only a few hours after the operation.

Necropsy.—The anatomic diagnosis was: "General arteriosclerosis; thrombosis of the superior mesenteric artery; hemorrhagic infarction of the small intestine; acute fibrinous peritonitis; embolism of the pulmonary artery; hemorrhagic infarction of the lungs."

CASE 10.—*History.*—L. W., woman, aged 45, white, admitted, March 15, 1913, was on the medical service for some time before being transferred to the surgical service. The diagnosis on the medical service was Raynaud's disease, thrombosis of the left iliac vein and phlebitis of the left leg. Ten days before admission to the surgical service, pain in the lower abdomen began and continued up to the time of operation. Vomiting began on the day before operation. On the day of operation, the temperature rose to 100 F., the pulse to 110. The leukocyte count was 31,000.

Physical Examination.—There was marked general abdominal tenderness, and some muscle spasm on both sides.

Operation (Dr. Finney).—"On opening the peritoneal cavity a mass was found in the upper abdomen. This mass proved to be several loops of intestine which were matted to each other and which were near the point of gangrene. The operator felt certain he had done nothing to relieve a volvulus and considered the condition to be one of mesenteric thrombosis. Thirty inches of intestine was removed and a lateral anastomosis done." The wound broke down after the operation and healed by granulation. On the eightieth day, June 3, the patient was discharged in fairly good general condition and with the abdominal incision entirely healed. On discharge the patient was having no abdominal symptoms and the signs of femoral thrombosis had almost entirely disappeared.

CASE 11.—*History.*—A. S., man, aged 38, white, admitted Oct. 15, 1913, with an entirely negative past history, for three days before entering the hospital had had severe pains in the abdomen. One day before admission, vomiting had begun and this had continued up to the time of operation.

Physical Examination.—The patient did not look very ill. He could walk around and take off his clothes without difficulty. The temperature was 98.6 F.,

the pulse, 80; respirations, 20, and leukocyte count, 9,000. The abdomen was markedly distended. There was moderate general abdominal tenderness and slight rigidity of the abdominal muscles.

Operation (Dr. Heuer).—"On opening the peritoneal cavity there was an escape of several ounces of bloody fluid. The intestines were greatly distended. About a foot above the cecum the ileum passed from normal to greatly thickened friable intestine. The mesentery supplying the involved intestine was several times its normal thickness. The thickened bowel was resected, a considerable amount of normal intestine being removed from either end and a lateral anastomosis done." The patient died a few hours after the operation, October 16. Permission for a necropsy was refused. The surgical pathologists reported that the resected intestine showed mesenteric thrombosis with necrosis of the intestinal mucosa.

Case 12.—*History.*—J. K., woman, aged 42, white, admitted to the hospital, Jan. 26, 1918, gave an essentially negative past history with no mention of any heart trouble. The present illness began with sudden severe pain in the epigastrium on the morning of the day on which the patient was admitted to the hospital. The pain quickly spread over the entire abdomen. There was some nausea but no vomiting. The patient's family physician gave her a cathartic and an hour later an enema; but these measures were insufficient to cause the bowels to move.

Physical Examination.—As the gynecologic extern, I saw this patient four hours after the onset of the symptoms and made the following note: "The patient is a young woman, lying in bed, complaining of considerable pain. She looks very ill, although her temperature by mouth is only 98 F., and her pulse, 90. The abdomen is normal in outline but moves only slightly with respiration. On palpation, moderate tenderness can be elicited over a central area extending about 6 cm. in all directions from the umbilicus. Over this area there is resistance but no true muscle spasm. There is no tenderness in the flanks and no dulness of the percussion note can be demonstrated. Pelvic and rectal examinations are negative." The patient was admitted to the hospital with the idea that she probably had a beginning intestinal obstruction. During the patient's first four hours in the hospital the abdomen became distended and extremely tender. Generalized abdominal rigidity developed. The white blood count in these four hours rose from 10,000 to 36,000, and the pulse rate from 80 to 150 to the minute. Eight hours after the onset of the patient's first symptom, a laparotomy was performed.

Operation (Dr. Wynne).—"On opening the peritoneal cavity a loop of distended small intestine was seen in the pelvis. This loop was quite black in color and the mesentery supplying it was also hemorrhagic. At either end there was a very definite line of demarcation between the normal and the infarcted intestine. The dark, distended intestine was resected and the two ends of the gut brought out through the upper angle of the midline incision. Drains were placed in both flanks through short McBurney incisions." Following the operation the patient's condition remained critical for several weeks. Most of the food eaten escaped from the cut end of the upper loop of intestine only slightly digested, so it was evident that the infarcted intestine must have been high up in the gastro-intestinal tract.

In addition to feeding the patient by mouth, we fed her peptonized milk and glucose through the lower loop of intestine. From that time on her condition gradually improved. Two unsuccessful attempts were made to close the

fecal fistula, extraperitoneally. On both occasions, end-to-end anastomoses were performed. Finally, July 10, 1918, a wide elliptic incision was made around the two enterostomy openings, an area of skin with some underlying fascia removed, the two ends of the intestine were brought out of the peritoneal cavity and resected, and a lateral anastomosis performed. This operation was performed by Dr. E. H. Richardson, as Dr. Wynne had then left the hospital for service in the Army. The patient was discharged six months after her first operation. The gynecologic pathologist, after examining the resected intestine with its attached mesentery, sustained the clinical diagnosis of intestinal infarction due to thrombosis of the mesenteric vessels.

CASE 13.—*History.*—B. C., woman, aged 31, white, admitted to the hospital, Feb. 8, 1921, gave an essentially negative past history with no mention of any cardiac trouble, and no history of any acute infection. Nine days before admission to the hospital, the patient began to have severe pain across the lower portion of the back and vomited once or twice on the day of onset of this pain. After eight days the backache suddenly disappeared and severe pain in the epigastrium commenced. That evening the vomiting recurred and the patient became delirious. On the following day, the day of admission to the hospital, the vomiting ceased, but the abdominal pain became generalized.

Physical Examination.—The patient complained of severe abdominal pain. The leukocyte count was 45,000; the red blood count, 7,680,000; hemoglobin, 112 per cent. The abdomen was moderately distended. Generalized abdominal tenderness was present and muscle spasm could be demonstrated over the whole abdomen.

Operation (Dr. Wharton).—"On opening the peritoneum, a considerable amount of slightly blood-tinged fluid poured out. A coil of small intestine lay transversely across the midline incision. This coil of intestine was moderately distended and quite black in color. There was no evidence of any obstruction. There was no pulsation in the vessels of the mesentery going to the discolored intestines and this portion of the mesentery had itself the same dark color. The operator did a resection of the infarcted intestine, removing in all 60 inches of intestine and then did a lateral anastomosis."

The patient stood the operation fairly well; but, after returning to the ward, her condition became progressively worse and the following day she died, February 9.

Necropsy.—The anatomic diagnosis was: "Polycythemia; atrophy of the liver; thrombosis of the branches of the portal veins in the liver with extension to the portal trunk and branches supplying the stomach, intestine, pancreas and spleen; hypoplasia of the bone marrow; infarction of the small intestine; acute peritonitis." It was the impression of Dr. Putnam, who performed this necropsy, that the thrombosis started in one of the branches of the portal vein inside the liver and extended downward to the branches of the portal vein supplying the ileum, duodenum, jejunum and cecum.

Case 14, my own case, was the one that aroused my interest in this subject and for that reason I am reporting it in considerable detail.

CASE 14.—*History.*—M. P., woman, aged 24, white, admitted Sept. 10, 1921, had had one attack of acute rheumatic fever two years previously, and slight edema of the ankles at times during the last six months. Otherwise her history was essentially negative. The patient had had a miscarriage ten days before admission to the hospital, followed by an entirely afebrile and uneventful puerperium. The evening before admission, while hanging

clothes on the line, the patient felt "something give way inside of her." At once abdominal pain and vomiting began. Dr. McCormick, of Sparrows Point, Maryland, saw the patient that evening and advised her to come into the hospital, but she refused. While the patient when first seen by Dr. McCormick looked quite ill, her temperature was still normal. During that evening and the next day the abdominal pain persisted and the vomiting occurred more frequently. The patient entered the hospital thirty hours after the onset of symptoms.

Physical Examination.—The patient was an undernourished young woman, apparently very ill. She was quite irrational. The temperature was 102 F.; the pulse rate, 120, and respirations, 30. The leukocyte count was 23,000. Examination of the lungs was negative. Examination of the heart gave a positive diagnosis of mitral stenosis and insufficiency, with probably beginning aortic insufficiency. The abdomen showed boardlike rigidity and generalized tenderness. The pelvis appeared normal. I recognized the fact that there was an acute condition of the abdomen, demanding operative interference. In considering the causes of the acute abdominal condition, volvulus and mesenteric thrombosis were mentioned, but no exact diagnosis was made.

Operation (Dr. Brady).—On opening the peritoneum a moderately distended, boggy, purplish black loop of small intestine appeared in the incision (Fig. 1). There was a small amount of serosanguineous fluid in the peritoneal cavity. All the loops of small intestine appeared somewhat distended; but only 16 inches (40.6 cm.) was dark purple. The mesentery supplying the dark intestine was the same purple color all the way down to its root. The line of demarcation between normal and infarcted intestine was very sharp at either end. I saw no volvulus and I feel sure I did not release any twist of the mesentery in delivering the intestine, as this part of the operation was performed quite slowly to avoid tearing the gangrenous intestine. All of the purple intestine, with an inch or two (2 or 5 cm.) of normal intestine at either end, was then removed. In doing this I took out as much as possible of the black mesentery. The two ends of intestine were temporarily closed and then brought out through a right McBurney incision, and three drains were placed in the lower angle of the midline incision to take care of the peritonitis which was already present. It was my impression at operation that the involved intestine was quite high up in the gastro-intestinal tract, although I did not stop to confirm my impression. The day after the operation I opened both ends of the intestine that were coming out through the McBurney incision. I did not known which end led to the stomach and which to the large intestine.

Course.—For three days the patient was in a critical condition, vomiting frequently and running a rapid pulse. On the fourth day fecal material began to come out through one of the enterostomy openings for the first time and from then on the patient's condition steadily improved. However, it was at once apparent that the material coming from the loop of intestine leading to the stomach was slightly digested food rather than fecal material. Charcoal given by mouth always appeared in an hour, and on one occasion, when the patient was apparently having diarrhea, charcoal appeared at the enterostomy opening fifteen minutes after being swallowed. On the fifth day, therefore, we began feeding the patient glucose and peptonized milk through the lower loop, as well as giving her everything she wished by mouth.

The patient's general condition steadily improved; but in spite of frequent dressings and the use of every known protective around the enterostomy open-

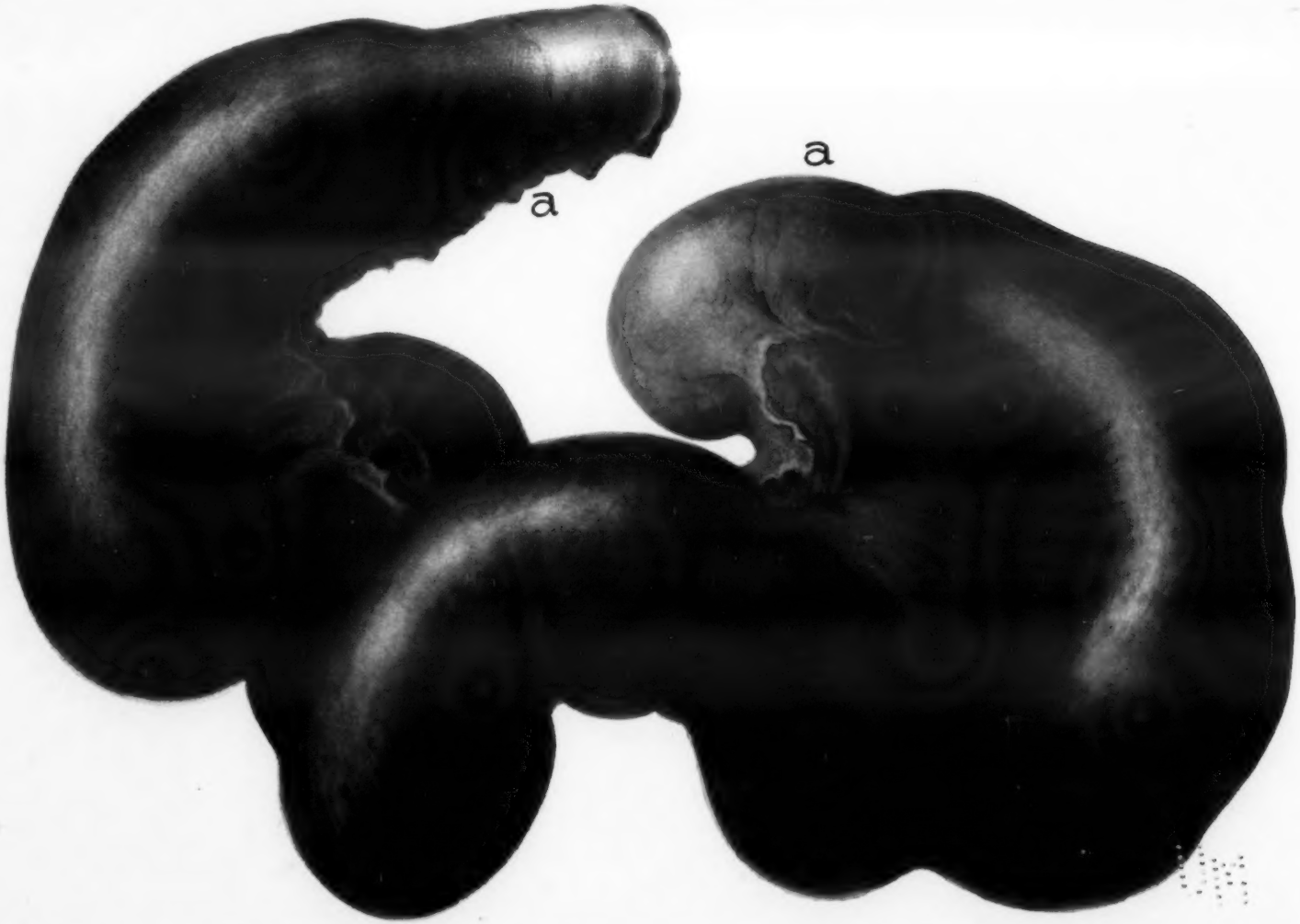

Fig. 1. — The purplish black of the intestine and of the mesentery extended to the root, as shown; *a*, *a*, sharp line of demarcation between the infarcted and normal intestine.

ings, it was evident that the secretions from the upper loop were beginning to digest away the skin. On the twentieth day we took all the dressings off the patient and put her in a continuous bath. We were able to do this, for by this time the midline incision had healed perfectly. Two days in the continuous bath improved the skin condition considerably; but we were afraid to continue this treatment as it was difficult to keep the water at exactly the right temperature. If the temperature of the water was a few degrees above body heat, the patient complained of weakness, whereas the slightest drop in temperature caused her to become cyanotic. October 3, twenty-three days after the first operation, a wide elliptic incision was made around the enterostomy openings; the skin with the adherent intestinal loops were brought out of the abdomen; the afferent and efferent cords divided about 2 inches (5 cm.) below the point where they came to the surface and a lateral anastomosis was performed. The patient recovered quickly from the second operation and was discharged two months after her first operation in very good general condition and with the two incisions well healed.

Comment.—Microscopic sections of the intestine removed at operation showed necrosis of the intestinal wall. Sections of the mesenteric vessels showed the lumen of the veins filled with antemortem blood clots and an accumulation of pus cells along the vessel walls. The arteries appeared normal. Figure 1 is a reproduction of a water color of the infarcted intestine as it appeared at operation. Figures 2 and 3 are low and high power photomicrographs of the mesentery. They show occlusion of the veins and the accumulation of leukocytes along the vein walls.

SUMMARY

1. Eleven of the fourteen cases of mesenteric vascular occlusion that have occurred in the Johns Hopkins Hospital produced intestinal infarction. In three instances, the thromboses progressed very slowly and sufficient collateral circulation developed to prevent the formation of an infarction. These three cases were, of course, recognized only at necropsy, as the patient had no symptoms referable to the thrombosis.

2. In thirteen of our cases, the superior mesenteric vessels were involved, in one instance the inferior.

3. The mesenteric arteries were involved in four cases, the veins in eight. In two cases it was impossible to tell which of the two caused the infarction. These findings are at variance with those of most observers, for in the majority of articles on this subject the veins are said to be involved much less frequently than the arteries.

4. When the mesenteric veins are occluded, it is always due to thrombosis. Either embolism or thrombosis may cause occlusion of the mesenteric arteries. In our series the four instances of occlusion of the mesenteric arteries are all recorded as being due to thrombosis. However, at necropsy it is frequently difficult to differentiate between thrombosis and embolism of the mesenteric arteries.

5. The average age of the patients in our series was 45 years. The oldest patient was 80, the youngest 24.

6. Eight of our patients were men; six women. Eleven were white; three were colored.

7. As causes of venous thrombosis all factors causing stasis of the portal system are of importance. Endocarditis, arteriosclerosis and any

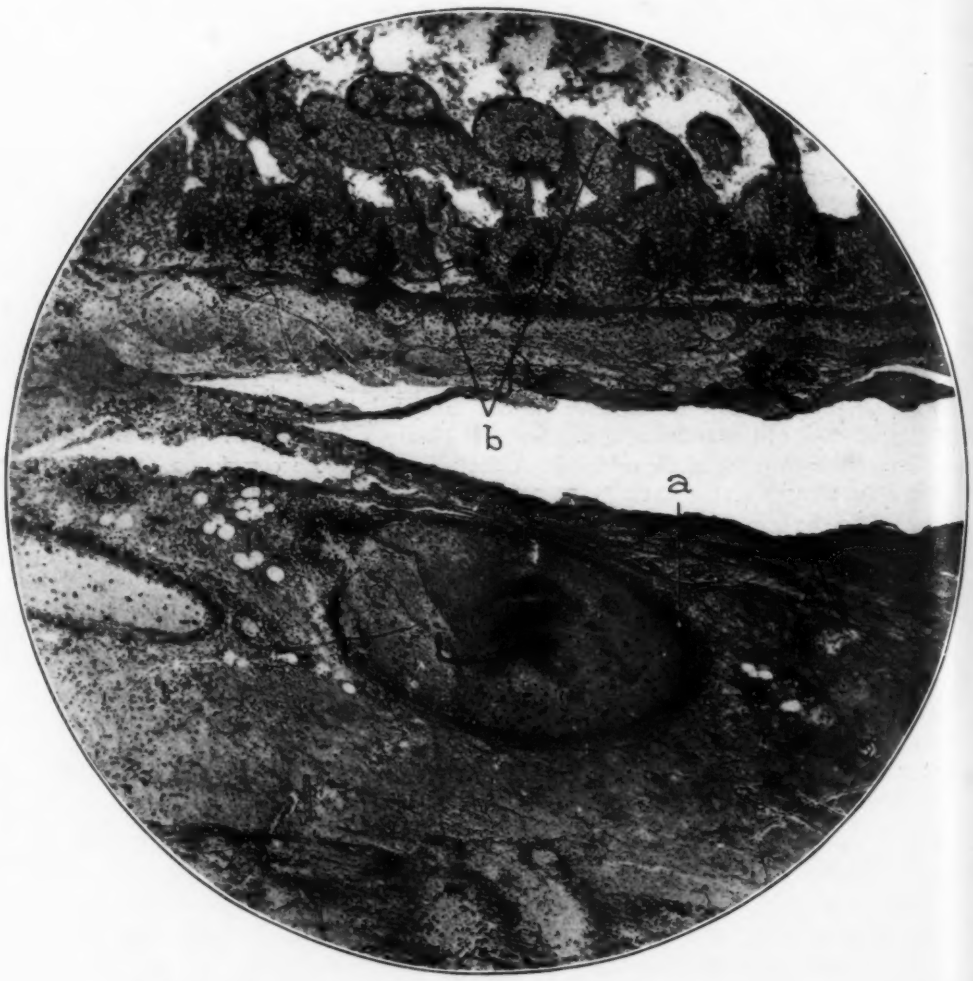

Fig. 2.—Low power photomicrograph of mesentery: (*a*) the accumulation of leukocytes along the thrombosed vein; (*b*) the necrotic intestinal villi.

condition leading to the formation of thrombi may be responsible for the mesenteric vascular occlusion. In ten of our cases, the following etiologic factors were found; in four we could find absolutely no cause for the occurrence of the thrombosis: endocarditis with aortic insufficiency and stenosis clinically, two patients; marked arteriosclerosis, two

patients; cirrhosis of the liver, 2 patients; Raynaud's disease, 1 patient; carcinoma of the pancreas with metastases to the liver and neighboring glands, 1 patient; polycythemia, 1 patient, and partially strangulated inguinal hernia with abscess formation, 1 patient.

Fig. 3.—High power photomicrograph of the thrombosed vein shown in Figure 2.

8. In all of our cases there has been a history of abdominal pain and vomiting, and on examination abdominal tenderness and muscle spasm were demonstrated. At the onset of the thrombosis there was little elevation of temperature; but at the end of twenty-four hours almost every patient had a temperature of at least 102 F. The leuko-

cyte count and the pulse rate usually rose before the temperature. In most cases the white blood count was 20,000 and the pulse rate at least 120 to the minute, even when the patient was seen within the first twelve hours after the onset of symptoms. Constipation was present in all of our patients; but in only two instances was there any passage of blood by rectum. The majority of our patients, even from the first, were greatly prostrated and looked ill.

9. In the majority of our cases of mesenteric vascular occlusion the progress of the condition was rapidly downward, with steadily increasing abdominal pain and with rising temperature and leukocyte count. For instance, one patient (Case 5) had abdominal symptoms for less than twenty-four hours before death, still at necropsy the entire small intestine was infarcted. Of course, the rapidity with which symptoms develop varies according to the size of the branch of the mesenteric vessel which is occluded; but in our series rapid progress downward has been the rule. Another patient (Case 7) affords the one exception to this rule. He had abdominal pain and vomiting for three weeks, and at necropsy only 3 feet (91.5 cm.) of small intestine was found to be infarcted. The accompanying table gives the duration of symptoms in our eleven cases of intestinal infarction.

DURATION OF SYMPTOMS IN ELEVEN CASES OF INTESTINAL INFARCTION

Number of Patients	Duration of Symptoms Before Operation or Death Days	Number of Patients	Duration of Symptoms Before Operation or Death Days
3	1	1	5
2	2	1	9
2	3	1	23
1	4		

10. Although some writers on this subject apparently believe there is a clinical picture which is diagnostic of mesenteric vascular occlusion, I have been compelled, from a study of our cases, to agree with those that maintain that the picture is indistinguishable from that of acute intestinal obstruction due to causes other than mesenteric thrombosis. If a patient with cirrhosis of the liver or endocarditis suddenly develops an acute abdominal condition, one may suspect a mesenteric thrombosis; but the instances in which one can say that "the patient has a mesenteric thrombosis and not a volvulus or strangulated hernia will probably always remain rare."

11. When the abdomen is opened in a case of mesenteric thrombosis, the peritoneal cavity is usually found to contain a moderate

amount of serosanguineous fluid. In advanced cases this fluid is frequently sanguineopurulent. The infarcted intestine is moderately distended and purplish black. The line of demarcation between normal and infarcted intestine is usually, but not always, sharp. The walls of the involved intestine feel soggy, and the intestinal lumen contains a considerable amount of fluid. The mesentery supplying the infarcted intestine is the same purplish black as the intestine, down to the root. Just how much inflammatory reaction the intestine not supplied by the thrombosed vessel shows depends on how far the secondary peritonitis has developed.

12. In intestinal infarction there is just one method of treatment—immediate laparotomy. Some surgeons believe that when the patient's general condition is sufficiently good to warrant prolonging the anesthesia for the necessary length of time, the proper operation is a resection of the intestine and a lateral anastomosis, whereas others believe that the anastomosis should never be performed at the primary operation. I agree with the latter view for these reasons: Patients with intestinal infarction are usually seriously ill, and an extensive intestinal resection with an anastomosis requires so much time and involves so much handling of the parts that the patients's endurance is likely to be overtaxed. Moreover, after the anastomosis has been completed, the vascular lesion with resulting infarction of the intestine may progress and cause the failure of an otherwise satisfactory operation. To quote from Moynihan[10]: "The safest measure to adopt in all cases is the resection of the bowel which is undoubtedly involved and the establishment of an artificial anus."

13. In very desperate cases and in cases in which a great many feet of intestine is found at operation to be gangrenous, the procedure advocated by Mikulicz may be carried out, that is, to bring all the gangrenous intestine out of the abdomen, to fix it parallel to the wound and to perform enterostomy, at a latter stage dealing with the gangrenous intestine. In this connection one of Dr. Thomas S. Cullen's cases is instructive.[11]

His patient had been operated on for a very large multilocular cystadenoma of the ovary. Six weeks later, while at her home apparently recovered from the first operation, she stooped over in her garden to pick something off the ground. She suddenly felt, as she expressed it, that something was wrong in her abdomen.

Dr. Cullen saw her on the second day, with her physician, Dr. J. C. Gilland, of Greencastle, Pa. She was transported 130 miles (208 km.)

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10. Moynihan, G. A.: Abdominal Operations, Philadelphia, W. B. Saunders Company **2**:1906.

11. Personal communication.

and the abdomen opened at the Church Home and Infirmary on the following day, three days after the onset of the trouble. On opening the abdomen Dr. Cullen found all but 2 feet (61 cm.) of the small bowel, brown and leathery. He at once recognized mesenteric thrombosis. Nothing could be done, so he merely placed two small cigaret drains in the abdomen and closed the incision. The patient lived for ten days after operation—in all thirteen days after the onset of the trouble.

14. In my own case the following procedure gave very satisfactory results: The infarcted intestine with about 2 inches (5 cm.) of good intestine at either end is resected through a lower abdominal midline incision. The two ends of the intestine are temporarily closed and brought out through a short McBurney incision. If drainage of the peritoneal cavity is indicated (and it is nearly always indicated in cases of intestinal infarction), it is carried out through the lower angle of the midline incision or through a McBurney incision on the side opposite that on which the enterostomy opening is to be. The McBurney incision should be made as far laterally as possible, so as to diminish the chances of infecting the midline incision. The advantages of having the enterostomy openings in a short McBurney rather than in a low midline incision are obvious. The midline incision does not so readily become infected and the closure of the enterostomy at the second operation is much simpler. The intestinal loops may be opened with safety a few hours after the operation; in fact, if the patient's condition is desperate, they may be opened sooner. It seems to be a good procedure to open not only the loop leading to the stomach but also the one leading to the rectum, for in the two cases I have seen treated in this way, there was a great deal of discharge from the lower loop for several days after the operation. Apparently, by antiperistaltic action, the normal intestine gets rid of the toxins which have undoubtedly poured into it from the infarcted intestine. Moreover, when the lesion is near the stomach, as it happened to be in these two cases, in addition to feeding the patient by mouth, water, peptonized milk and glucose should be introduced into the lower loop.

At the second operation, an incision is made around the enterostomies; the two ends of intestine with perhaps 1 cm. of surrounding skin fascia and peritoneum are brought out of the peritoneal cavity in one block and a resection and lateral anastomosis are performed. By first entering the peritoneal cavity several centimeters above the enterostomies and introducing a finger into the abdomen, one can perform the block dissection of the abdominal wall without fear of injuring the intestine. The use of the continuous bath for several days before the second operation will often improve markedly the condition of the

patient's skin, but one must use great care in keeping the water at exactly the correct temperature.

15. Since the mesenteric vascular occlusion in three of our fourteen cases played no part in causing the patient's death, I feel justified in omitting those cases when calculating the mortality. Eight of the eleven cases of mesenteric vascular occlusion that caused intestinal infarction proved fatal—giving a mortality of 72.5 per cent. Five of our eight patients treated by laparotomy died—an operative mortality of 62.5 per cent. These seem to be high figures, but when one learns that in 1904, Jackson, Porter and Quinby reported a total mortality of 94 per cent. and an operative mortality of 92 per cent. for all the cases known to have occurred up to that time, one realizes how peculiarly fortunate we have been in this clinic.

16. The hope of saving the lives of more patients with mesenteric vascular occlusion lies in recognizing promptly not necessarily that these patients have a mesenteric thrombosis, but that they have an acute abdominal condition demanding surgical interference.

BILATERAL CHRONIC OPEN PNEUMOTHORAX CURED BY NEGATIVE TENSION

REPORT OF CASE *

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The use of negative tension in cases of subacute and chronic empyema, in which pronounced thickening of the visceral pleura is absent, has a very definite field of usefulness, as is illustrated by the case here described.

REPORT OF CASE

History.—A man, aged 21, a resident of Troy, Vermont, was admitted to the Montreal General Hospital, May 18, 1920, with the history, given by his physician, Dr. Adams, that the patient had developed influenza, complicated by pneumonia, Jan. 29, 1920. February 25, at the patient's home, an intercostal thoracotomy was performed for the drainage of a right-sided empyema. Later he was removed to a hospital in Massachusetts, and, March 23, a left-sided empyema was relieved by intercostal drainage. Both wounds continued to discharge foul-smelling pus. The temperature ranged between 99 and 101 F., with occasional exacerbations, accompanied by chills. The patient lost ground steadily. There was progressive emaciation and the development of pronounced anemia.

May 17, approximately three months from the date of drainage of the right-sided empyema, the relatives of the patient decided to remove him from the hospital to his home, as no hope could be held out for his recovery. While en route to Vermont, it was decided to bring the patient to Montreal. He was admitted to the Montreal General Hospital, May 18, in a critical condition.

Examination.—The emaciation was the most extreme that I have ever witnessed. There was urgent air hunger, all of the accessory muscles of respiration being brought into play. With each inspiratory act, the mandible was depressed and the tongue pushed forward. The face was cyanosed. There were audible rhonchi. Thoracic movements were limited to the left upper half of the chest.

Course.—Shortly after admission, a serious collapse occurred and death was thought to be imminent. The patient, however, responded to hypodermic injections of camphor and atropin.

As soon as this condition permitted, a roentgenogram was taken and the thoracotomy wounds inspected. Through that on the right side, which was 2 cm. in diameter and situated in the sixth intercostal space in the midscapular line, could be seen, at each inspiration, the movement of the collapsed right lung toward the opposite side. From this wound there was a moderate amount of thick foul discharge.

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* Read before the Fourth Annual Meeting of the American Association for Thoracic Surgery, Boston, June 6, 1921.

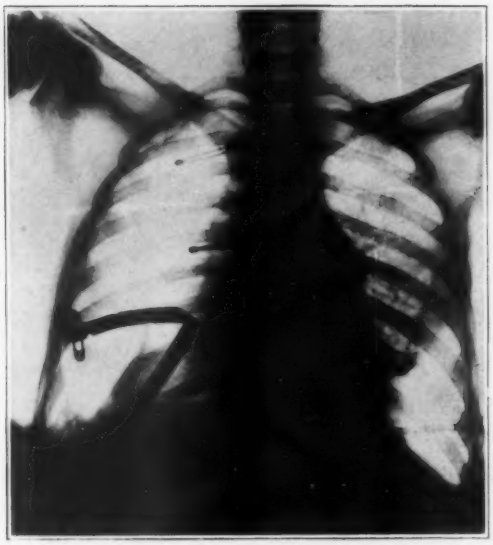

Fig. 1.—Complete collapse of the right lung and partial collapse of the left lung. The lung shadow on the left side, immediately above the cavity, is denser than normal. The tube in the right pleural cavity was one which was lost six weeks before admission, and extracted through the old thoracotomy wound, shortly after the patient entered the hospital. As evidence of the extreme emaciation, the absence of soft tissue contours should be noted in Figures 1, 2 and 3.

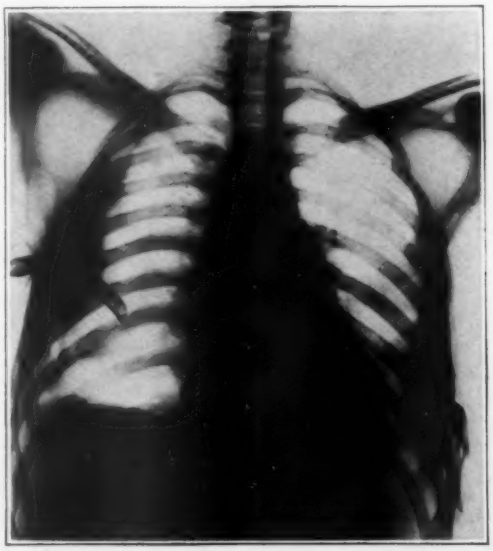

Fig. 2.—Cavity on the right side and almost complete obliteration of the cavity on the left, with disappearance of the area of increased density, in the latter location, occupying the middle zone shown in Figure 1; reduced about one-third.

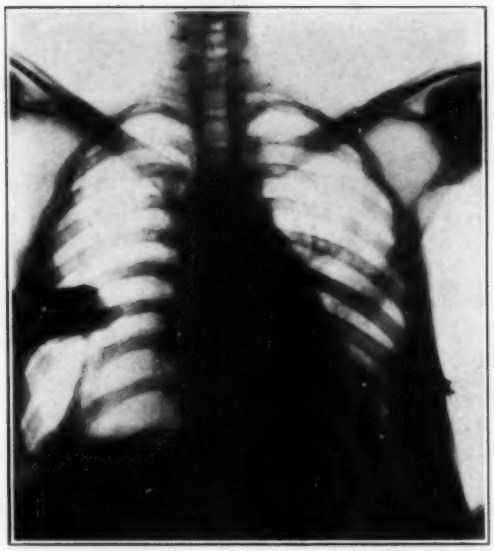

Fig. 3.—Cavity on the right side, with only a sinus remaining on the left side; reduced about two-thirds.

Fig. 4.—Small residual cavity on the right, containing 5 c.c. of bismuth paste.

On the left side a drainage tract was placed in the seventh intercostal space in the posterior axillary line, which was about 1 cm. in diameter. The discharge was similar to that on the right side. There was a complete right-sided pneumothorax, while on the left only the lower lobe was collapsed. Any attempt to turn the patient toward the left side increased the dyspnea.

A negative tension apparatus was adjusted on the right side, with immediate lessening of the respiratory distress, giving play, as it did, to the uncollapsed portion of the left lung. Up to this point it would appear that the patient had been living on tidal air, with little or no vital capacity. On the following day, May 19, negative tension was induced in the cavity on the left side. During the ensuing fortnight this man passed through several respiratory crises, which were relieved by the administration of morphin and atropin.

Subsequently, there was rapid recovery of the appetite. The patient remained afebrile. The roentgenograms revealed progressive reexpansion of both lungs. August 2, approximately eleven weeks after admission, he was discharged with both cavities obliterated.

COMMENT

The extent of the emaciation may be gaged by the fact that, after the display of an exceptionally vigorous appetite for several weeks before leaving the hospital, the patient's weight, estimated on admission to be about 70 pounds (31.7 kg.), on the day of discharge was only 104 pounds (47 kg.). In October, two months after discharge, he weighed 134 (61 kg.), and in December, 147 pounds (66.8 kg.). In October he resumed work as a clerk in his father's store, and has since been in normal health. I think it is an undeniable fact that this patient would have died but for the employment of negative tension. The drainage apparatus employed in this case was similar to the apparatus that I [1] described in 1911.

219 Peel Street.

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1. Eberts, E. M.: Ann. Surg. **54**:58, 1911.

OUTLINE OF TREATMENT OF FRACTURES

SYLLABUS ADOPTED AT THE BOSTON CONFERENCE, APRIL, 1922

For a long time now, and especially since the armistice, there has been a strong desire among surgeons to simplify and standardize the treatment of fractures. The individual preferences were, before the war, so diverse that this seemed impossible, and since the war few have believed that any group of men could get together and agree on the essentials of the treatment of fractures. At a medical meeting held in January, 1922, it was suggested that an attempt be made by a group of men interested in fractures to come to some agreement as to the treatment of the more frequent ones. Those present suggested that the Massachusetts General Hospital call the meeting, as the first fracture service had been established there, in 1917, by Dr. Charles L. Scudder.

The suggestion was taken up and the men who have signed this syllabus gathered at the Massachusetts General Hospital in April, 1922, and agreed on the syllabus herewith appended, except in a few minor details which did not seem to be of vital importance.

The apparent unanimity of the group on all the essentials was so unexpected and seemed so important that it was determined to publish the syllabus as a guide for those who might desire some assistance. It can obviously carry only the weight of the experience of the surgeons attending the conference. In regard to certain details, there are naturally minor differences of opinion.

The following surgeons have agreed to the essentials of the syllabus: James M. Hitzrot, William Darrach, Fordyce B. St. John and Seth M. Milliken, New York; W. Irving Clark, Jr., Worcester, Mass.; Fred J. Tees, Campbell B. Keenan and Fraser B. Gurd, Montreal, Canada; Fred A. Coller, Ann Arbor, Mich.; George W. Hawley, Bridgeport, Conn.; William S. Baer, Baltimore; Astley P. C. Ashhurst and George M. Dorrance, Philadelphia; Paul B. Magnuson, Chicago; W. O'Neill Sherman, Pittsburgh; Murray S. Danforth, Providence, R. I.; Charles L. Scudder, Fred J. Cotton, Daniel F. Jones, Robert B. Osgood, Zabdiel B. Adams, Henry C. Marble, Torr W. Harmer, Philip D. Wilson, Arthur W. Allen, and George A. Leland, Jr., Boston.

OUTLINE OF TREATMENT OF FRACTURES

I. First Aid.

Every effort should be made to avoid any injury additional to that of the original trauma.

1. "Splint 'em where they lie!"
2. Avoid every unnecessary manipulation.
3. Transport with extreme care.
4. Treat any existing shock.

II. Examination.

As complete and thorough an examination as possible should be made without causing any additional injury.

1. Begin with painless procedures.
2. Search for crepitus and abnormal mobility only when these symptoms are absolutely essential. The manipulation required to elicit these cause additional injuries.
3. Rule out, if possible, other associated injuries, especially those of nerves.
4. Elicit objective symptoms, which will be painful, only under an anesthetic.
5. Roentgen-ray examination should be made as early as possible; roentgenograms should be taken in two planes, stereoscopic when necessary; should be of sufficient size, and should be studied with detailed care.

III. Diagnosis.

The simple diagnosis that a fracture exists is not sufficient. All details of pathology of the soft parts, as well as of the bone, should be considered, so as to visualize properly the problem of obtaining and maintaining reduction as well as the problem of repair and its probable duration.

IV. Treatment.

Each fracture should be considered as an individual problem and the treatment directed not only to the injury of the bone but to that of the soft parts as well. The pathologic changes following a fracture interfere markedly with the ease of reduction of displaced fragments. These changes begin very soon after the injury. Infiltration of the adjacent soft parts, coagulation and later organization of the blood are the most important.

1. Obtaining Reduction.
   - (*a*) Reduction of any existing displacement should be made as soon after the injury as possible, without waiting too many hours for the roentgen-ray examination.
   - (*b*) Reduction should be as gentle as possible.
   - (*c*) Reduction should be as complete as the individual case requires.
   - (*d*) Reduction may be controlled by fluoroscopic examination in appropriate cases.
   - (*e*) Reduction should be checked by a roentgen-ray examination as soon as practical.
   - (*f*) Manipulation should be carried out under an anesthetic with but few exceptions.
   - (*g*) Further attempts at reduction should be made as soon as the need is recognized.
2. Maintaining Reduction.
   - (*a*) Decide in each case the peculiar problem presented, and select apparatus accordingly, both for immediate and subsequent use.
   - (*b*) A decision should be reached as to how early such apparatus can be temporarily discarded to allow for massage and motion, and how long it should be worn, in order to protect against further injury.

(*c*) Repair in cancellous is more rapid than in cortical bone.
(*d*) Rapidity of repair will depend very largely on the blood supply of the fragments.
(*e*) The atrophy of disuse must be borne in mind.
(*f*) The inherent value of any apparatus is of less importance than the skill with which it is used.

3. Plaster of Paris.

Circular plaster bandages are permissible only when completely divided in at least one line.

4. Massage and Movements.

If carefully and gently carried out, massage and movements can be of the greatest help. If roughly performed, they may do considerable harm. One must differentiate, under massage, between:

(*a*) Gentle stroking without deep pressure.
(*b*) Stroking with deep pressure.
(*c*) Kneading.

One must differentiate between:

(*a*) Guided active motion.
(*b*) Unaided active motion.
(*c*) Passive motion.

With these differences in mind, the various forms of each may be begun as soon as there is no danger of any additional injury or any displacement of the fragments resulting. This gentle massage and movements may cause discomfort but should never cause actual pain. The pain of forced passive movements usually means harmful stretching or tearing of soft parts, with additional necessary repair.

V. Operative Treatment.

Operative treatment is indicated when a satisfactory reduction cannot be obtained and maintained by nonoperative methods, provided there is no contraindication, and when the expected result of the open method is sufficiently better than that of the closed to justify the additional risk.

Futhermore, it is generally recognized and accepted that, in certain types of fractures, it is impossible to obtain satisfactory restitution except by operative methods.

The operative method is recommended to those surgeons who have had special training and experience, who have the necessary skill and judgment, and who have the hospital facilities and surgical armamentarium with which to do this work properly. In the case of those who do not have such facilities, operation is not advised.

Internal splinting of long bones is usually best made by fixation, with steel plates and screws, having a minimum of foreign material but with maximum strength and ductility. The machine type screw only should be used. The wood, or so-called carpenter, screws are contraindicated in the cortex of bones. A scrupulous nonhand contact technic should be carried out, with strict attention to detail. The

skin should be carefully covered during the operation, and there should be special care and preparation of the skin before operation. Intramedullary fixation by bone graft or splints is contraindicated if any other method is possible.

Bone grafting is indicated chiefly in loss of substance and pseudoarthrosis. It is not indicated in the treatment of acute fractures. Every attempt to stimulate osteogenesis should be exerted before attempting to bone-graft for delayed union.

VI. Compound Fractures.

In all compound fractures, patients are to receive tetanus antitoxin.

Compound fractures in which it is perfectly evident that the wound of the soft parts is made by the protrusion of bone from within outward through the skin, and in which the wound is tiny, should have a thorough preparation of the skin by washing with benzin, shaving (away from the wound), drying with ether and the application of tincture of iodin to the skin and the wound itself, with sterile dressing. Immediate reduction should be undertaken when indicated.

When a roentgen-ray examination is to be made before reduction, all the steps enumerated above, except reduction, are to be completed before the patient is sent to the roentgen-ray department.

In extensive compound fractures with a large wound:

1. Apply tourniquet only when it is obvious that some large vessel has been lacerated.
2. With a sterile sponge, carefully protect the wound from contamination while the skin is being cleansed, following the foregoing routine; in addition, chlorinated soda solution 1:40 may be found of value in removing grease. If this procedure can be undertaken without too much pain and shock to the patient, it should be carried out before he is sent to the roentgen-ray department; if not, apply tincture of iodin only to the edges of the wound, and put on a large sterile dressing before roentgen-ray examination, and complete the procedure when the patient is under anesthesia.
3. At operation, débridement:
   - (*a*) Thorough exposure of wound by generous incisions.
   - (*b*) Excision en bloc of traumatized and infected tissues.
   - (*c*) Excision of skin at least 0.5 cm. from the wound edges.
   - (*d*) Dead and dying fat, fascia and muscle cut away with sharp instruments until fresh bleeding occurs.
   - (*e*) Small bone fragments unattached to periosteum removed; soiled bone surfaces rongeured.
   - (*f*) Hematoma dissecting between muscle planes should be carefully evacuated.
   - (*g*) Frequent changes of gloves and instruments to insure against carrying infection into deep portions of wound.
   - (*h*) Irrigation of the wound with salt solution to wash out particles of dirt, if necessary.
4. Final dressing of wound, according to indication:
   - (*a*) Complete closure after lavage with ether or iodin.
   - (*b*) Application of Carrel tubes for immediate use of surgical solution of chlorinated soda (Dakin's solution).

Schematic Tabulation of Treatment of Fractures

Bone	Part of Bone	Reduction	Immobilization	Position	Secondary Splinting (Duration)	Convalescent Brace (Duration)	Physiotherapy (Time to Begin)	
							Massage	Active Motion
Clavicle.....	Outer, mid, inner thirds	Manipulation with or without anesthesia	Clavicular cross, no sling necessary	Shoulders back, up and out	1. Same, 3 to 5 weeks.... 2. Recumbency in dorsal decubitus with posterior pad; 10 days to 3 weeks	None Clavicular cross, 2 wks.	None None	Immediate 3 wks.
Scapula.....	1. Body.....	No manipulation.....	Sling with or without adhesive	Arm to side.....	1. Same, 3 weeks.....	Sling, 1 to 2 wks.	1 wk.	2 to 4 wks.
	2. Neck.....	Manipulation with or without anesthesia	Sling and axillary pad	Arm to side.....	2. a. Same, 3 weeks, b. or without swathe, 1 to 2 weeks c. Recumbency (for those displaced)	Sling, 1 wk.	1 to 3 wks.	4 wks.
Shoulder.... (Humerus)	1. Anatomic neck 2. Surgical neck:							
	a. Impacted.....	a. No manipulation...	.....	a. Arm to side or abduction	a. Same, 2 to 3 days.....	a. Sling, 3 wks.	3 days	3 days
	I. Without marked displacement (as for a) II. With marked displacement (as for d)		Axillary pad (sweat pad only); circular bandage; cravat sling or as per d (omit for c)					
	b. Incomplete..... (children)	b. No manipulation...		b. Arm to side.....	b. Same, 1 to 3 weeks....	b. Sling, 2 to 3 wks.	Not necessary	1 to 3 wks.
	c. Epiphysis.....	c. Manipulation with anatomic reposition with anesthesia		c. Arm to side or abduction	c. Same, 3 to 4 weeks....	c. Sling, 2 to 3 wks.	Not necessary	2 to 4 wks.
	d. Unimpacted.....	d. Manipulation with or without anesthesia	Abduction and traction by Thomas arm or aeroplane splints or as for a	d. Abduction or arm to side	d. Same, 4 to 6 weeks....	d. Sling, 1 to 2 wks.	3 days	2 to 4 wks.
	e. Fracture dislocation	e. Careful manipulation with or without anesthesia	Traction in Thomas arm splint	e. Abduction.....	Operation; plaster-of-Paris or aeroplane splint; 4 to 6 weeks	Sling, 2 to 4 wks.	2 to 5 wks.	2 to 5 wks.
	3. Greater tuberosity..	No manipulation.....	Aeroplane splint or plaster spica	Abduction and external rotation	1. Same, 3 to 5 weeks.... 2. Operation if necessary	Sling, 1 to 2 wks.	1 to 5 wks.	3 to 5 wks.
Humerus....	4. Shaft: a. Upper and mid thirds (above insertion of deltoid)	Manipulation with or without anesthesia	1. Hinged Thomas arm splint 2. Jones humerus splint with or without coaptation splints, avoiding axillary pressure 3. Axillary pad, circular and sling to wrist	Arm to side.....	Same, 4 to 8 weeks.....	Coaptation splints and sling, 2 to 4 wks.	1 to 3 wks.	4 to 8 wks. (shoulder)

Humerus....	b. Lower third.....	Manipulation with or without anesthesia	1. Jones humerus splint 2. Axillary pad, sling to wrist and circular with internal (anterior) angular or molded plaster splints	Suspension or arm to side	Same, 4 to 8 weeks.....	Coaptation splints and sling, 2 to 4 wks.	1 to 3 wks.	3 to 6 wks. (elbow)
	5. Supracondylar or lower humeral epiphysis a. Lower fragment posterior b. Lower fragment anterior	Manipulation with or without anesthesia to anatomic reposition (traction with elbow in hyperextension)	1. Adhesive strapping 2. Aluminum internal (anterior) angular splint 3. Molded plaster external or internal angular splint 4. Bandage and sling	a. Acute flexion.....	Same, 10 to 14 days.....	Sling, 1 to 2 wks.	3 days to 2 wks.	1 to 3 wks.
				b. Right angle flexion	Same, 10 to 14 days.....	Sling, 1 to 2 wks.	3 days to 2 wks.	1 to 3 wks.
	6. Epicondyle.....	Same as 5, a.....	Same as 5, a.....	Same as 5, a.....	1. Same as 5, a or	Same as 5,a	Same as 5,a	Same as 5,a
	7. Internal condyle....	Same as 5, a.....	Same as 5, a.....	Same as 5, a.....	2. Operation if necessary	Same as 5,a	Same as 5,a	Same as 5,a
	8. External condyle...	Same as 5, a.....	Same as 5, a.....	Same as 5, a.....		Same as 5,a	Same as 5,a	Same as 5,a
	9. T-fracture into joint	Manipulation with or without anesthesia	1. Traction by Thomas arm splint or Jones humerus splint, or suspension with immediate active motion (right angle elbow)	1. Extension or right angle	1. Same, 4 to 6 weeks....	Sling, 2 to 3 wks.	1 to 3 wks.	2 to 4 wks.
				2. Right angle flexion	2. Open reduction plaster, 3 weeks	Sling, 2 to 3 wks.	3 wks.	2 to 4 wks.
	10. Capitellum.....	Manipulation with or without anesthesia	1. Same as 5, a.....	Acute flexion.....	1. Same as 5, a, 3 to 5 weeks	Sling, 1 to 3 wks.	1 to 3 wks.	3 to 5 wks.
				Acute flexion.....	2. Open reduction if necessary; same as 5,a 2 to 4 weeks	Sling, 1 to 3 wks.	1 to 3 wks.	3 to 5 wks.
Ulna.....	1. Olecranon.....	No manipulation.....	1. Extension with molded plaster splint from axilla to palm 2. Thomas arm splint	1. Extension to 160 degrees 2. Extension or partial flexion	1. Same, 2 to 4 weeks.... 2. Open reduction where marked separation	Sling, 2 wks. (gradually increasing flexion)	1 to 2 wks.	1 to 3 wks.
	2. Coronoid.....	Manipulation with or without anesthesia	Same as humerus, 5, a	Complete flexion generally	Same, 2 to 4 weeks.....	Sling, 2 wks.	1 wk.	2 wks.
Radius.....	1. Head: a. Not displaced.....	No manipulation.....	a. Right angle splinting	1.a. Right angle in 2.a. full supination	1.a. Same, 2 to 3 weeks..	1.a. Sling, 2 wks.	1 wk.	Flexion, 1 wk.; pronation, supination, 2 wks.
	b. Displaced.....	Manipulation with or without anesthesia	b. Same as humerus, 5, a	.....	1.b. Excision of fragment or head; same, 2 to 3 weeks	1.b. Sling, 2 wks.	1 wk.	Flexion, pronation, supination, 1 wk.
	2. Neck: a. Not displaced....	No manipulation.....	a. Right angle splinting	1.b. Acute flexion... 2.b.	2.a. Same, 2 to 4 weeks..	2.a. Sling, 2 wks.	1 wk.	Flexion, pronation, supination, 2 to 3 wks.

SCHEMATIC TABULATION OF TREATMENT OF FRACTURES—(*Continued*)

Bone	Part of Bone	Reduction	Immobilization	Position	Secondary Splinting (Duration)	Convalescent Brace (Duration)	Physiotherapy (Time to Begin)	
							Massage	Active Motion
Radius.....	b. Displaced.....	Manipulation with or without anesthesia	b. Same as humerus, 5, a	.....	2.b. Same as 1,b, 5 to 7 weeks	2.b. Sling, 2 wks.	1 wk.	Flexion, pronation, supination, 2 to 3 wks.
Forearm....	1. Both bones.....	Manipulation with or without anesthesia	1. a. Anterior and posterior wooden splints and anterior right angular splint, or molded posterior plaster splint b. Molded anterior and posterior plaster splints to include palm c. Plaster axilla to palm d. Traction and suspension	1. Forearm supinated; elbow flexed at right angle	Same, 5 to 7 weeks; children, 3 to 5 weeks..	Sling, 2 to 3 wks. Sling, 3 to 6 wks.	1 to 4 wks.	4 to 6 wks.
				2. Upper third (above insertion of pronator teres); supination with elbow at right angle; below insertion of pronator teres, pronation with elbow at right angle	Same, 4 to 6 weeks.....	Sling, 2 to 3 wks.	1 to 3 wks.	2 to 4 wks
	2. Radius (alone).....	Manipulation with or without anesthesia	2. Same as 1 a, b or c.					
	3. Ulna (alone).....	Manipulation with or without anesthesia	3. Same as 1 a, b or c.	3. Midpronation....	Same, 3 to 4 weeks.....	Sling, 2 to 3 wks.	1 to 3 wks.	2 to 4 wks.
	4. Greenstick.....	Manipulation with or without anesthesia	4. Same as 1 a, b or c.	4. Supination with elbow at right angle	Same, 3 to 5 weeks.....	Sling, 2 to 4 wks.	Not necessary	2 to 4 wks.
					or 1, 2 and 3..... a. Traction, 3 to 6 weeks 1. Jones humerus splint 2. Overhead suspension, 4 to 6 weeks b. Open reduction	Sling or plaster, 2 to 3 wks.	3 to 6 wks.	3 to 6 wks.
Radius.....	1. Lower extremity with Colles' displacement, epiphyseal separation	Under anesthesia; after mobilization reduce existing deformities, including torsion and ulnar luxation	a. Anterior and posterior wooden splints with cutout for ulnar styloid with fingers free b. Plaster.....	1.a. Hand adducted and pronated with palmar flexion b. In bad displacements, extreme of foregoing position	1. Same, 2 to 3 weeks....	a. Wrist strap, 1 to 5 wks. b. Wrist strap, 2 to 6 wks.	2 days to 3 wks.	1 to 3 wks.
	2. Same without displacement	No manipulation.....	a. Wooden splint..... b. Plaster.....	2. Same as 1.....	2. Same, 2 to 3 weeks....	Wrist strap, 2 to 6 wks.	2 to 7 days	2 to 7 days
	3. Same with displacement, not Colles'	Same as for 1.....	Same as for 1.....	3. Hand adducted and slight dorsal flexion	3. Same, 2 to 3 weeks....	Wrist strap, 2 to 6 wks.	2 days to 3 wks.	1 to 3 wks.

Carpus.....	Scaphoid, semilunar, all others: a. Not displaced.....	No manipulation.....	Molded plaster anterior cock-up splint from elbow to finger tips	Dorsal flexion of hand in position of grasp	Same, 4 to 6 weeks..... or	Wrist strap, 2 to 6 wks.	1 to 3 wks.	4 to 6 wks.
	b. Displaced.....	Manipulation with anesthesia			Reduction of displaced fragment by open reduction with cock-up for 4 to 6 weeks	Wrist strap, 2 to 6 wks.	1 to 3 wks.	4 to 6 wks.
Metacarpus.	Bennett's.....	Manipulation with anesthesia	Traction in small banjo splint	Hyperextension.....	Same, 3 weeks.....	None	1 to 3 wks.	3 wks.
	Metacarpals. a. Not displaced.....	No manipulation.....	Convex palmar splint	a. Position of grasp	Same, 2 to 4 weeks.....	None	2 days	1 to 2 wks.
	b. Displaced.....	Manipulation with anesthesia if necessary	Traction in small banjo splint with cock-up to palm	b. Extension.....	Same, 3 to 5 weeks.....	None	1 wk.	2 to 3 wks.
Phalanges...	a. Not displaced.....	No manipulation.....	Palmar splint for injured and adjacent fingers or traction	a. Partial flexion...	Same, 2 weeks.....	None	Immediate to 1 wk.	1 wk.
	b. Displaced.....	Manipulation with anesthesia	Traction in small banjo splint	b. Partial flexion...	Same, 2 weeks.....	Palmar splint, 1 wk.	1 wk.	2 wks.
Ribs.....	.....	No manipulation.....	Adhesive strapping (two thirds circumference) with arms dependent	Full expiration.....	10 days to 2 weeks.....	None	None	None
Pelvis.....	1. Any bone or combination	Reduction if possible with or without anesthesia	Swathe; if necessary, with suspension in Balkan frame or Sinclair net bed	Supine.....	Same, 4 to 12 weeks.....	Belt	None	5 to 8 wks.
	2. Iliac crest.....	No manipulation.....	Tight swathe not advised	Supine.....	Same, 4 to 12 weeks.....	None	None	5 to 8 wks.
	3. Acetabulum with penetration of head of femur	Manipulation with anesthesia	a. Traction (Maxwell-Ruth) b. Plaster spica (in abduction)	a. b. Abduction.....	Same, 6 to 12 weeks.....	Caliper	1 wk.	6 to 12 wks.
Femur.....	1. Neck: a. Impacted, not displaced b. Unimpacted, displaced	Manipulation with or without anesthesia	Thomas splint with skin traction from knee to ankle as emergency	Full abduction, extension, internal rotation (Whitman position)	Plaster spica extending to toes with short spica to opposite thigh, or carried to opposite axilla; 12 to 15 weeks	Caliper and crutches, 6 to 9 mos.; no weight bearing for 6 to 9 mos.	12 to 15 wks.	12 to 15 wks.
	2. Intertrochanteric and base of neck	Manipulation with or without anesthesia	Thomas splint with skin traction from knee to ankle as emergency	Usually slight abduction	Abduction plaster spica or traction in Thomas splint, 8 weeks, or Maxwell-Ruth method	Caliper and crutches, 4 to 6 mos.; patient to be up as soon as union is firm	Immediate	Hip, 8 wks.; knee, 4 to 6 wks.

SCHEMATIC TABULATION OF TREATMENT OF FRACTURES—(*Continued*)

Bone	Part of Bone	Reduction	Immobilization	Position	Secondary Splinting (Duration)	Convalescent Brace (Duration)	Physiotherapy (Time to Begin)	
							Massage	Active Motion
Femur.....	3. Shaft: a. Adult.....	Manipulation with or without anesthesia	Thomas splint with skin traction from knee to ankle as emergency	Hip flexion: knee flexion and abduction often necessary in fractures from trochanters to midthigh; maintain normal anterior convexity of femur	Traction in Thomas splint (followed by 1. Skin traction (carried well above line of fracture), total traction, 5 to 9 weeks, or 2. Skeletal traction from condyles of femur (under proper conditions)	Caliper and crutches, 3 to 6 mos.	Immediate	Knee, 2 to 4 wks.
	b. Children (not more than 6 yrs.)	Manipulation with or without anesthesia	Thomas splint with skin traction from knee to ankle as emergency	1. Hip flexion; knee extension 2. Slight flexion of hip and knee	1. Overhead traction (on Bradford frame preferred), 6 weeks 2. Plaster spica (if reduction is satisfactory)	Plaster spica or long molded plaster side splint from axilla to below knee 4 to 6 wks.	Not necessary	8 to 12 wks.
	4. Supracondylar.....	No manipulation; anesthesia if necessary for pain	Thomas splint with skin traction from knee to ankle as emergency	Hip flexion; knee flexion sufficient to maintain position	1. Skeletal traction from condyles of femur in Thomas splint (under proper conditions), followed by skin traction if necessary; total traction, 5 to 9 weeks 2. Plaster spica (if reduction is satisfactory) 3. Operation if necessary	Caliper and crutches, 3 to 6 mos.	Immediate, if possible	Knee, 2 to 4 wks.
	5. T-fracture into knee joint	No manipulation.....	Thomas splint with skin traction from knee to ankle as emergency	Hip flexion; slight knee flexion	1. Skeletal traction from head of tibia (under proper conditions) in Thomas splint, 5 to 9 weeks 2. Plaster spica (if reduction is satisfactory)*	Caliper and crutches, 3 to 6 mos.	Immediate, if possible	Early
	6. Separation of lower epiphysis	Manipulation with anesthesia (immediate)	Plaster toes to groin	Acute knee flexion..	Same, 3 to 4 weeks.....	Plaster cylinder with gradual extension of knee	2 wks.	3 to 4 wks.
Patella.....	a. With separation....	No manipulation.....	Cabot posterior or similar splint (prepare for operation)	Extension.....	Operation after 3 to 8 days 1. Cabot posterior or similar splint 2. Molded plaster, malleoli to buttock, 1 to 3 weeks	Molded plaster posterior or caliper, 4 to 10 wks.	Immediate, if possible	As soon as skin wound is healed

* The conference considers this fracture very serious, requiring skilful treatment; by operation, if necessary.

Patella.....	b. Without separation	No manipulation.....	Cabot posterior or similar splint (operation not necessary)	Same.....	Same, 1 to 3 weeks.....	Same	Same	1 to 2 wks.
Tibia.....	Tuberosities: a. With separation..	Manipulation, if necessary, with or without anesthesia	Cabot posterior or similar splint	Extension.....	1. Manipulation with lateral clamp if necessary; plaster toes to groin, 4 to 6 weeks 2. Skin traction in Thomas splint, 4 to 6 weeks	Caliper, 4 to 12 wks.	Immediate, if possible	Immediate, if possible
	b. Without separation	No manipulation.....	Plaster toes to groin	Extension.....	Same, 4 to 6 weeks.....	Caliper, 5 to 12 wks.	2 to 7 wks.	4 to 6 wks.
Tibia.....	Shaft with or without fibula	a. Manipulation with or without anesthesia b. Delbet method without anesthesia (excellent)	1. Molded plaster splint, or 2. Plaster toes to groin (with or without posterior wooden splint)	Slight knee flexion; foot at right angles; avoid rotation	Same, 6 to 8 weeks or skeletal traction in Thomas (especially in oblique fracture of lower third), 4 to 6 weeks; operation if necessary	Caliper or Delbet, 4 to 8 wks.; plaster, caliper, Delbet, 4 to 10 wks.	1 to 3 wks. Immediate, if possible	4 to 6 wks. Immediate
Fibula.....	Shaft.....	Manipulation, if necessary, with or without anesthesia	1. Molded plaster splint, toes to knee or groin depending on level of fracture 2. Cabot or similar splint	Slight knee flexion..	Same, 3 to 4 weeks; in fractures near head, special attention must be paid to external popliteal (peroneal) nerve	Not necessary	3 to 4 wks.	2 to 4 wks.
Ankle.....	1. Inversion (adduction) 2. Eversion (abduction), Pott's, and outward rotation a. Without displacement b. With displacement	Manipulation with anesthesia if necessary a. No manipulation... b. Manipulation, if necessary, with or without anesthesia	Plaster toes to knee.. Plaster toes to knee.. Plaster toes to above knee	1. Eversion (abduction), moderate 2. a and b. Dorsiflexion and inversion (adduction) of foot with reduction of displacements, especially posterior displacement	Same, 4 to 6 weeks..... Same, 4 to 6 weeks.....	Short caliper if necessary a. Short caiper; foot plate if necessary; Thomas heel (forward ¾ to 1 in., inner border raised ¼ in.) b. Same	1 day to 1 wk. 1 day to 1 wk. 1 day to 1 wk.	2 to 3 wks. 2 to 6 wks. 2 to 6 wks.
Os calcis.....	.....	Manipulation with anesthesia when necessary	Pillow and side splints temporarily	Slight plantar flexion and inversion (adduction), or plantar and knee flexion	Plaster boot to knee or groin; operative manipulation necessary for those with displacement, 4 to 6 weeks*	Foot plate or Thomas heel	2 to 3 wks.	4 to 6 wks.
Tarsus.....	.....	Manipulation with anesthesia if necessary	Pillow and side splints temporarily	Right angle flexion and inversion (adduction)	Plaster boot with molding, 4 to 6 weeks; operation if necessary	Foot plate or Thomas heel	3 to 4 wks.	4 to 6 wks.
Metatarsus..	a. Not displaced..... b. Displaced.....	No manipulation..... No manipulation.....	Molded plaster to tibial tubercle Pillow and side splints	Right angle flexion and inversion (adduction) Right angle flexion and inversion (adduction)	Same, 4 to 6 weeks..... Traction in banjo splint, 4 to 6 weeks, or operation	Foot plate or Thomas heel	3 to 4 wks.	4 to 6 wks.

* The conference considers this fracture very serious, requiring skilful treatment; by operation, if necessary.

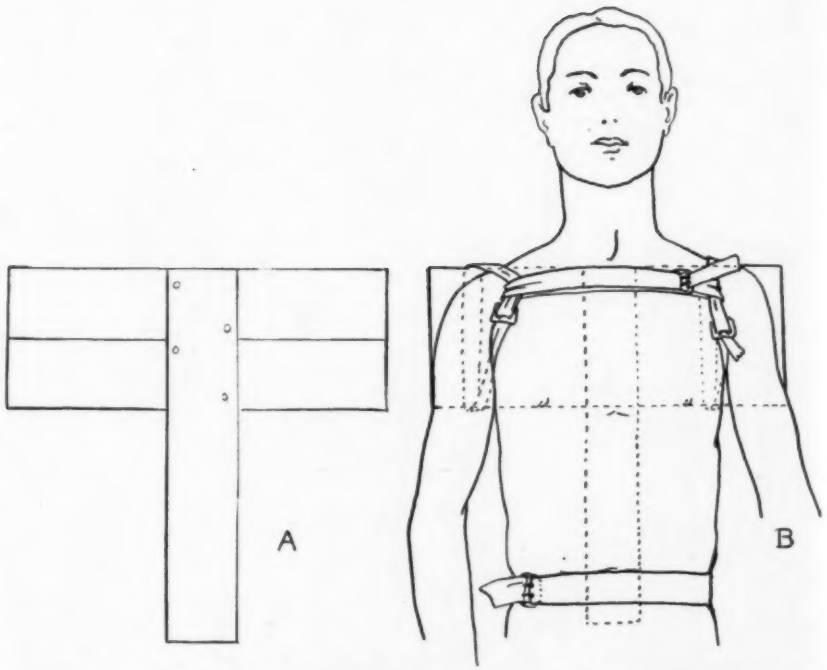

Fig. 1.—*A*, clavicular cross (made of splint board), the two pieces, the width of the shoulder, being tacked to a vertical piece reaching from the shoulder to the sacrum; *B*, method of application of clavicular cross (for purposes of simplification the padding is not shown). The surface of the splint in contact with the skin should be abundantly padded with cotton and covered with bandage. The affected shoulder is lifted up, back and out and secured to the cross arms of the splint by straps or a figure-of-8 bandage. The lower part of the vertical pieces is pushed in close to the sacrum and held by adhesive or buckle straps.

Figure 2

Figure 3

Fig. 2.—Thomas traction arm splint (Murray pattern): The ring is padded with felt and covered with leather and is hinged at its points of junction with the frame.

Fig. 3.—Method of application of Thomas traction arm splint (Murray pattern) in fracture of the upper end of the humerus: Adhesive traction strips are applied to the upper arm, traction being obtained by weight and pulley. The arm is supported on flannel or canvas strips pinned to the side bars of the splint. The elbow may be flexed, as shown, and suspended by means of additional traction strips to an overhead frame; or it may be placed in the extended position, in which case only one pair of traction strips, extending from the wrist nearly to the axilla, is used.

Figure 4

Figure 5

Fig. 4.—Axillary sweat pad and wrist sling, showing the narrow width of the sling.

Fig. 5.—Plaster-of-Paris jacket, with shoulder spica and forearm casing holding the arm in the abducted position.

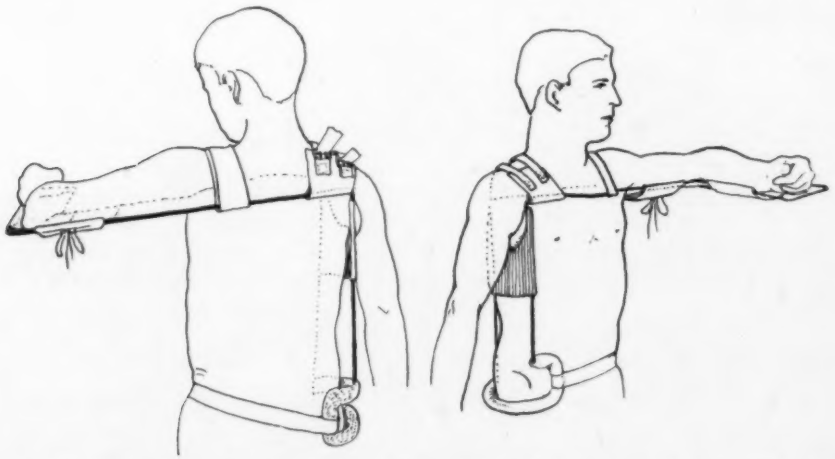

Fig. 6.—Anterior and posterior views of aeroplane splint (Cleary type), the lower support of which rests against the iliac crest.

Figure 7

Figure 8

Fig. 7.—Jones humerus traction splint.

Fig. 8.—Method of application of Jones humerus traction splint: Traction may be obtained as indicated by means of a strap passing over the upper end of the forearm, in which case a thick felt pad should be interposed between it and the skin. In other cases, traction is obtained by adhesive strips applied to the mesial and lateral skin surfaces of the upper arm.

Figure 9

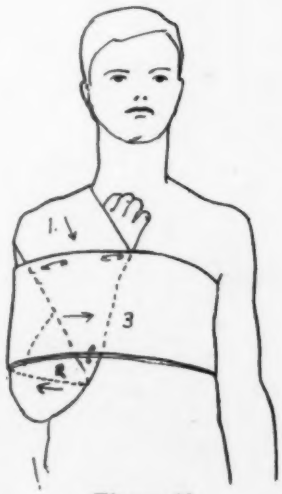

Figure 10

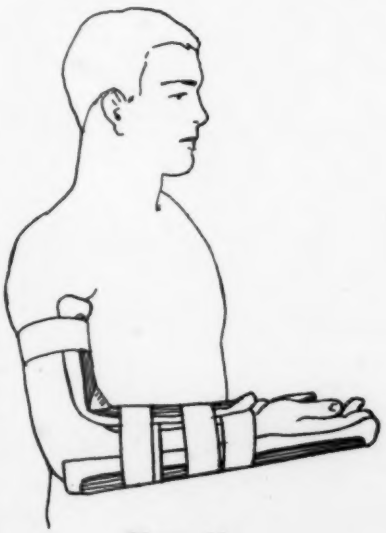

Figure 11

Fig. 9.—Molded plaster posterior splint, holding the elbow in the position of acute flexion.

Fig. 10.—Lund swathe: A long muslin strip is folded to a width of 4 inches (10 cm.). One end is placed on the dorsal spine and unrolled over the affected shoulder, vertically downward across the forearm, under the elbow and then back across the elbow, and around the chest as a bandage. The free ends are fixed to adjacent folds with safety pins.

Fig. 11.—Anterior and posterior wooden splints with anterior angular aluminum splint, as used in fracture of the bones of the forearm.

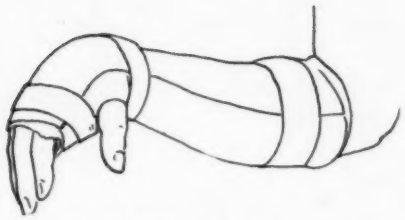

Fig. 12.—Colles' fracture plaster splint, illustrating the extreme position of pronation, adduction and wrist flexion in which it may be necessary to place the hand after reduction of certain cases of Colles' fracture.

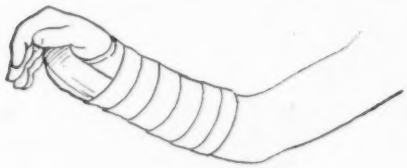

Figure 13

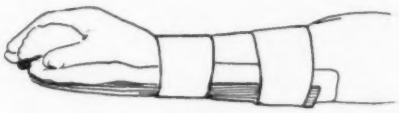

Figure 14

Fig. 13.—Plaster cock-up splint employed in certain cases of injury about the wrist.

Fig. 14.—Long plaster cock-up splint holding the hand in the position of grasp, as required in fracture of the carpal scaphoid.

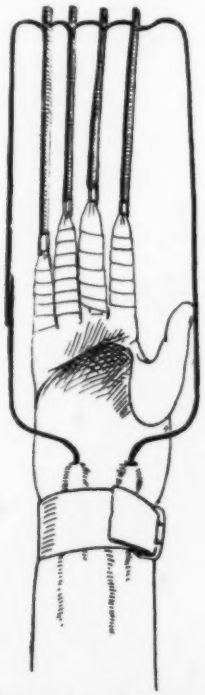

Fig. 15.—Banjo splint (indicated in fractures of the metacarpals with displacement and in certain fractures of the phalanges): The splint is made of a molded plaster strip applied to the forearm, in which is incorporated a wire frame appropriately bent to meet the indication. The traction is obtained by adhesive strips fastened to the fingers and elastic tubing connecting these with the wire frame. One or all the fingers may be included, as necessary.

Fig. 16.—Bradford frame: Canvas strips are laced across the frame, which is made of ordinary gas pipe, in such a way as to leave an appropriate interval for the buttocks under which the bed pan may be passed.

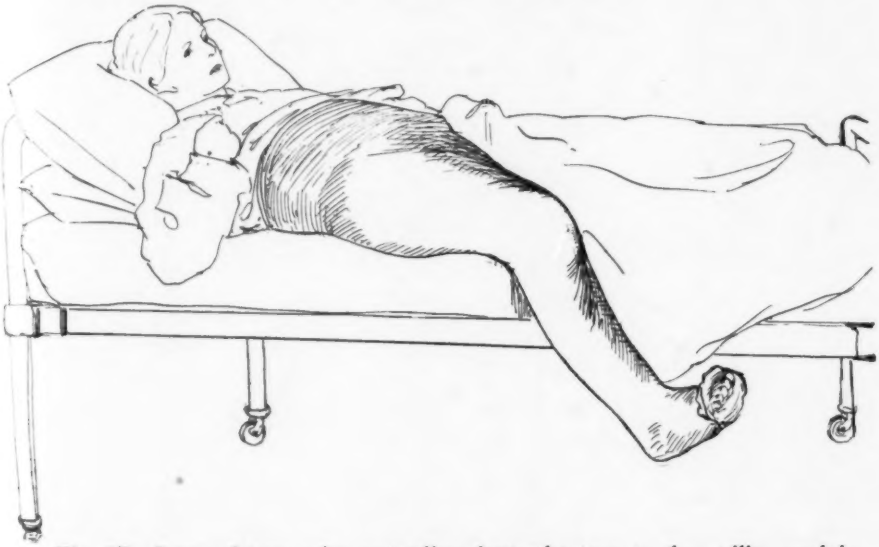

Fig. 17.—Long plaster spica extending from the toes to the axilla. used in fractures of the neck of the femur to hold the hip in the position of abduction, extension and internal rotation.

Fig. 18.—Thomas traction leg splint.

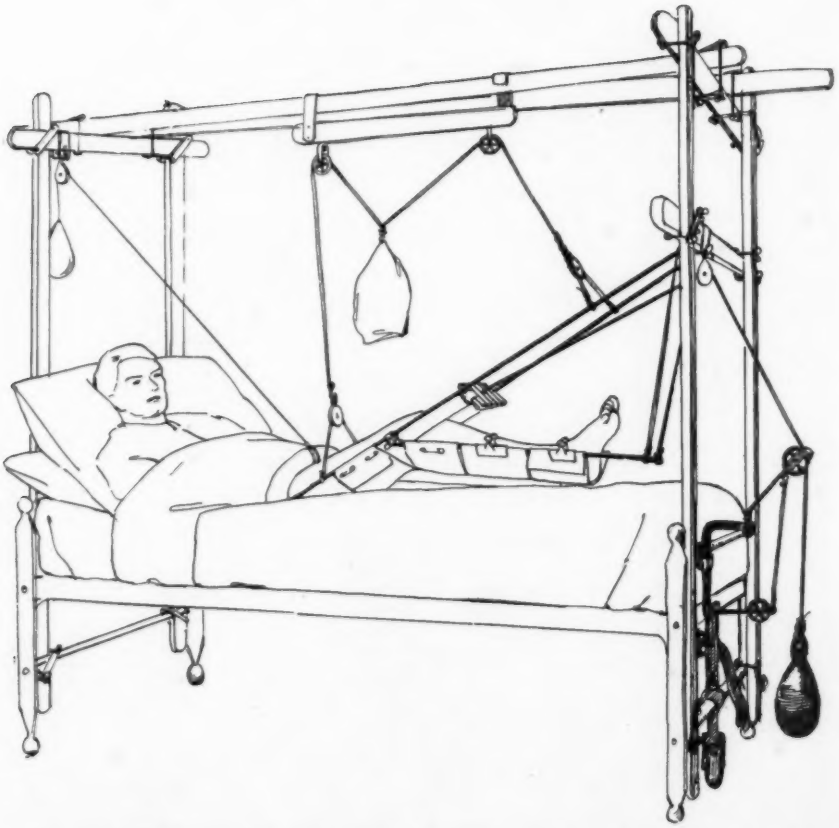

Fig. 19.—Balkan frame, illustrating the method of applying and suspending the Thomas traction leg splint with the hinged knee attachment.

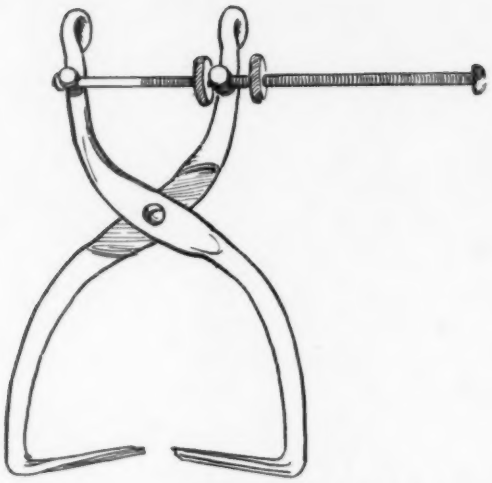

Fig. 20.—Calipers (Adams type) for direct skeletal traction on the femoral condyles.

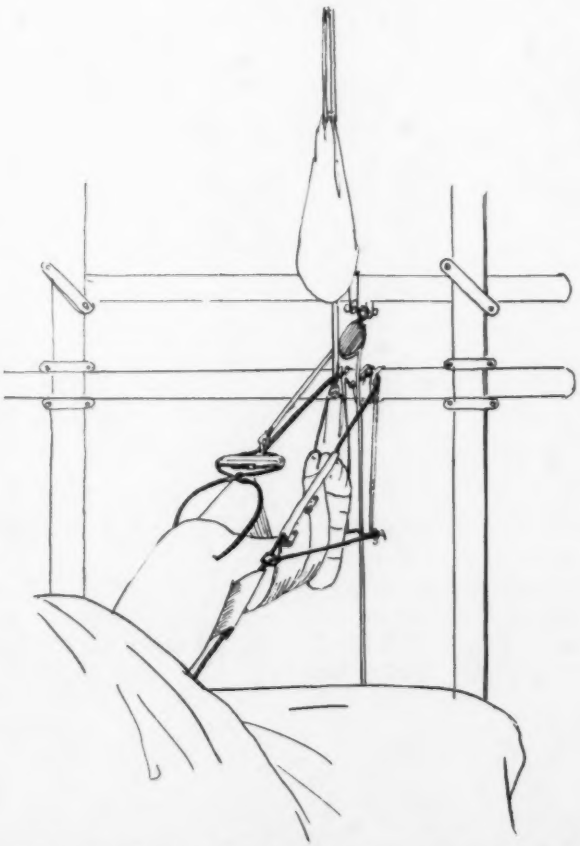

Fig. 21.—Skeletal traction in fractures of the femur: The points are introduced on a horizontal plane one-half inch (1.3 cm.) above and in front of the adductor tubercle.

Fig. 22.—Thomas caliper splint: The lower ends of the splint fit into the heel of the shoe, and part of the body weight is transmitted to the ground by the direct thrust of the rings against the tuberosity of the ischium. The opposite shoe should be slightly elevated.

Fig. 23.—Rainbow frame. The overhead traction as used in fractures of the femur in young children is illustrated. The child is lying on a Bradford frame.

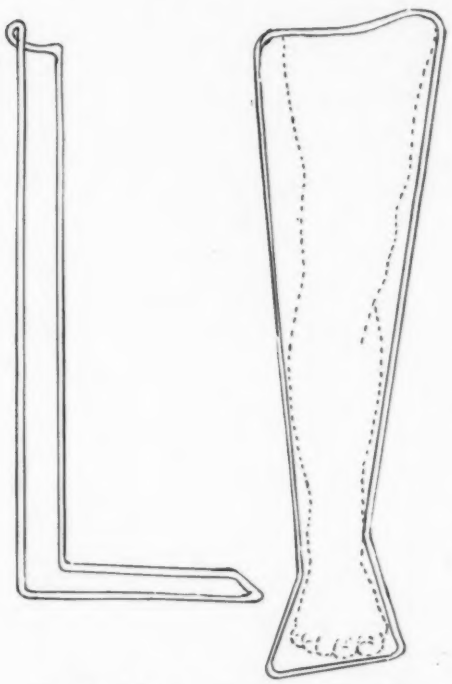

Fig. 24.—Cabot posterior wire splint.

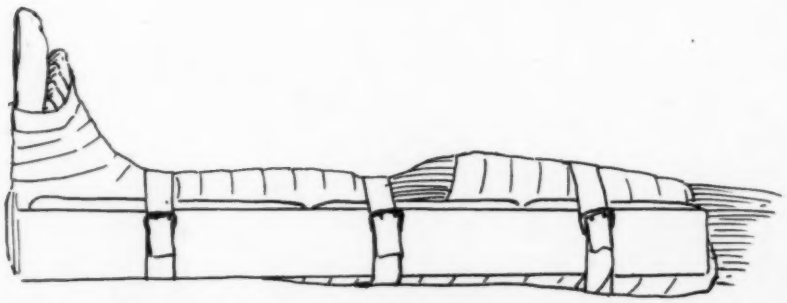

Fig. 25.—Cabot posterior wire splint applied with side splints in injuries about the knee.

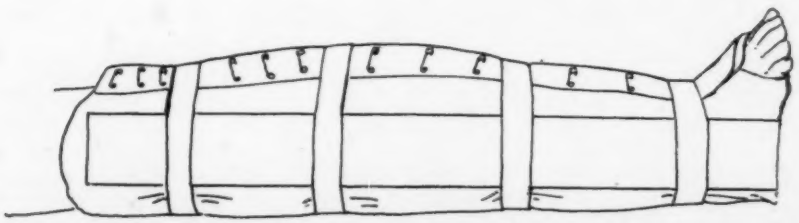

Fig. 26.—Pillow splint with lateral and posterior wooden splints, used as an emergency dressing in fractures of the leg.

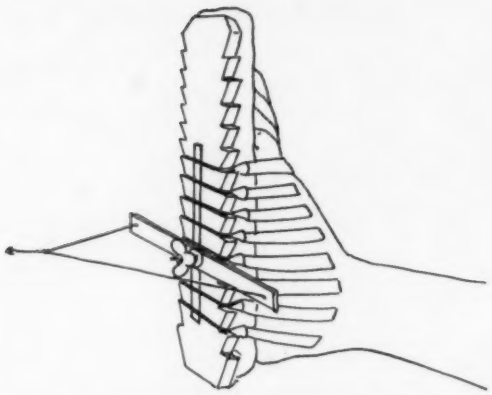

Fig. 27.—Method of application of Sinclair skate to obtain traction in certain fractures of the lower leg.

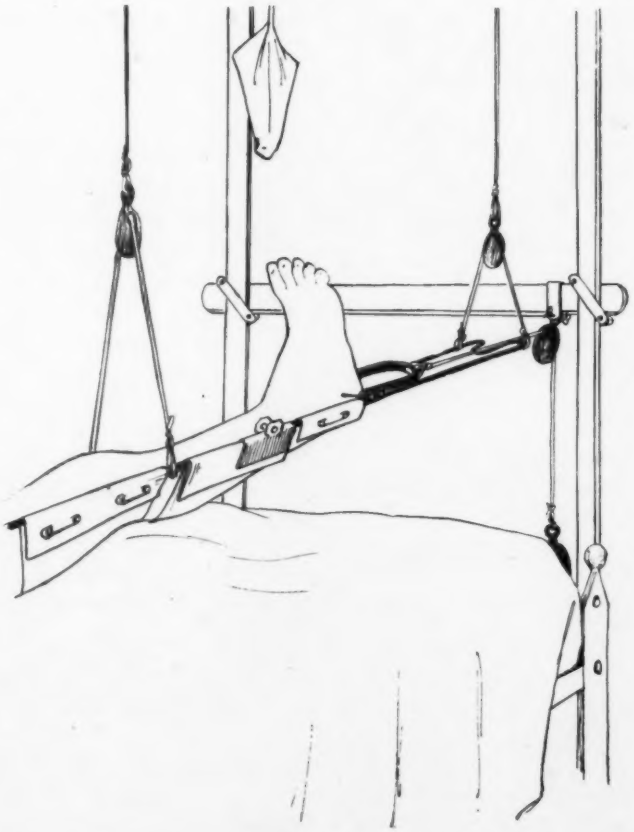

Fig. 28.—Skeletal traction on the os calcis: A Steinmann or similar steel pin is passed through the heel either over the top or through the center of the os calcis. To this pin, by means of an appropriate clamp, traction by means of weight and pulley is attached (used in connection with the Thomas traction leg splint).

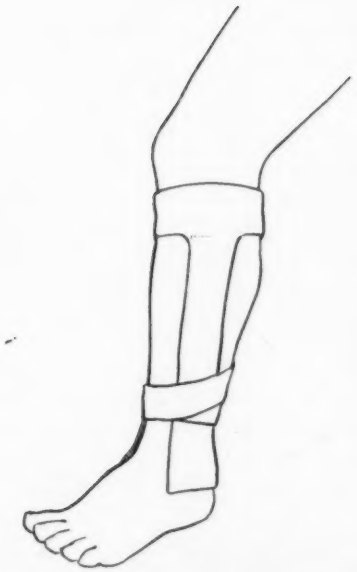

Fig. 29.—Delbet plaster splint: Plaster strips are molded snugly without padding to the leg, one encircling the upper end of the tibia, two vertical strips on the mesial and lateral aspects of the leg, and one spiral strip holding them in position. Weight is transmitted from the upper end of the tibia to the plaster strips and by them carried to the malleoli. It is used as a convalescent brace.

NINETEENTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY *

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BOSTON

CONGENITAL CONDITIONS

Hypophyseal Lesions and Congenital Deformities.—Samaja,[1] reporting a case of congenital deformities of the lower extremities in a twin, associated with an abnormality of the sella turcica, suggests the possible relationship of congenital deformities to changes in the hypophysis.

Congenital Torticollis.—Fränkel,[2] on the basis of sixty-one cases in which operation was performed without relapse, advocates early open operation by means of a transverse incision in the crease of the neck near the lower end of the muscle. The muscle is isolated and divided, and, if the fascia has been cut transversely, it is sutured longitudinally. Only one insertion of the muscle is divided if correction can be accomplished by this. A plaster cast is applied in overcorrection, with traction away from the shoulder operated on.

[ED. NOTE.—We believe it is nearly always wiser to divide both insertions and all contracted fascial bands if one is to avoid relapses. We also have encountered rather alarming symptoms of respiratory distress during, and sometimes following, the application of an overcorrecting cast while the patient is still under an anesthetic. We consider it safer and quite as satisfactory to retain the correction by head traction and sandbags for the first twenty-four hours at least, and then to apply the retentive cast when the patient is conscious.]

Cervical Rib.—Taylor [3] has written a valuable paper on cervical ribs, with special reference to their surgical treatment. Their well known variation in size is no criterion as to the severity of the symptoms, and, with even the most rudimentary forms, there is usually found an aponeurotic band running from their tips downward to an attachment to the first true rib, which may cause the same symptoms as a complete cervical rib.

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* This Report of Progress is based on a review of 398 articles selected from 477 titles dealing with orthopedic surgery, appearing in medical literature between Jan. 21, 1922, and May 21, 1922. Only those papers which seem to represent progress have been selected for note and comment.

1. Samaja: Chir. d. org. di movimento **5**:690 (Dec.) 1921.
2. Fränkel: Arch. f. klin. Chir. **118**:228 (Nov. 24) 1921.
3. Taylor: New York State J. M. **22**:97 (March) 1922.

When these accessory ribs are present, the subclavian artery is placed at a higher level than normally, and when there is a bony connection between the cervical rib and the first true rib, the artery crosses the true rib just in front of the bony projection. The motor, sensory and vasomotor pressure symptoms are evident about the thirtieth year, often after some debilitating illness, and are caused by the impingement of the eighth cervical and first dorsal roots on the false rib, as these roots arch over its superior surface.

The sensory symptoms are usually first to appear, affecting the ulnar side of the forearm and hand, and may be expected to progress unless treatment is begun. Motor disturbances of insidious onset ensue, and atrophy of the small hand muscles, leading in some untreated cases to claw hand.

If the symptoms are of sufficient severity to demand operation for the removal of the accessory rib, the author advocates an anterolateral approach through an incision, beginning at the posterior border of the insertion of the sternomastoid, passing upward and outward to the border of the trapezius at an angle of 45 degrees with the clavicle. The cervical fascia is divided along the outer border of the plexus, which is separated from its bed posteriorly sufficiently to expose the rib and allow gentle retraction of the plexus forward. If the cervical rib is buried in the scalenus medius muscle, the palpation of the carotid tubercle serves as a guide. All muscular and ligamentous attachments to the rib are divided by sharp dissection in order to leave the periosteum intact. Care must be taken not to open the pleura. The head and neck are finally freed, and the intimate relationships of the seventh cervical root and the vertebral artery must be borne in mind. If the vertebral artery is wounded, it must be ligated at its origin. It is of great importance to have good illumination. As much of the rib as possible is removed, an attempt to enucleate cleanly the head and neck being made, though not always successfully. The aponeurotic extension must be divided. The wound is closed without drainage.

Taylor considers the advantages of this method of approach to be the following: (*a*) It is sufficiently free to make possible complete removal and control of bleeding. (*b*) It necessitates a minimum manipulation of the plexus. (*c*) The whole dissection follows natural lines of anatomic cleavage. (*d*) The scar is inconspicuous.

Five cases are reported and the article is well illustrated.

[Ed. Note.—We commented in the last (Eighteenth) Progress on the work of Sir Harold Stiles on this subject, and the variations which occur in the formation of the plexus, in the so-called prefixed and postfixed types. In the postfixed or lower formation type, a "rocking" true first dorsal rib may cause the same train of pressure symptoms as a cervical rib.

It is an interesting fact that the symptoms of pressure from cervical or first dorsal ribs ordinarily do not arise until the person is well advanced in adult life, Taylor says at about 30 years, and often following some debilitating illness. Since the anatomic variation has been present since birth and yet given rise to no symptoms until many years after full growth has been attained, there must be other factors which influence the onset of symptoms. We believe one of these factors is the faulty postures which often become more or less habitual in later life, and which, if unrelieved, may well cause a nerve to impinge on a cervical or even on a first dorsal rib, giving rise to the typical symptoms and signs above mentioned. Careful training in bodily mechanics and correct body and neck postures may bring about a subsidence of symptoms, and this attempt in early cases might well be made before the rather difficult operative procedure is undertaken.

We have also encountered numerous cases of neuritic symptoms in the arms closely simulating rib pressure symptoms, even to small hand muscle atrophy, which were associated with a cervical arthritis. It has been possible to demonstrate this arthritis of the hypertrophic type in roentgenograms in patients between 30 and 40, as well as in older patients. Fixation of the neck by a Thomas collar and physiotherapeutic measures applied to the cervical spine have resulted in a disappearance of the arm symptoms. These cases emphasize the importance of taking lateral and anteroposterior roentgenograms of the whole cervical spine, as well as views of the cervical rib region.]

Congenital Elevation of the Scapula.—Salaghi,[4] in reporting a case of congenital elevation of one scapula due to malformation of several ribs and an associated scoliosis, inveighs against the use of proper names in designating a condition. In his case, there were no abnormal attachments of the scapula to the spine, nor any muscular contractures. No operative procedures were required, and, if the scoliosis could have been corrected, the elevation of the scapula would have been corrected as well. To speak of the case as Sprengel's deformity would not properly describe the condition.

[ED. NOTE.—The Editors in previous Reports of Progress have found occasion also to plead for the general abandonment of the use of proper names to describe lesions or diseases. We shall probably not escape from certain classical exceptions, sanctioned by long usage, but Salaghi's point is well taken. Proper names, unless one is familiar with the literature, fail to suggest pathologic conditions and can never be descriptive.]

König's Operation for Congenital Elevation of the Scapula.—Grauhan[5] has obtained such a satisfactory result from König's opera-

4. Salaghi: Policlinico **28**:521 (Dec. 15) 1921.
5. Grauhan: Arch. f. orthop. **19**:408, 1921.

tion in a 17 year old patient with congenital elevation of the scapula that he considers the operation should have a wider employment. In his case, there was union of the transverse processes of the second and third dorsal vertebrae on the left to the mesial border of the scapula. The supraspinous portion of the scapula was prominent at the front of the neck, and the arm could be elevated only slightly beyond the horizontal plane. There was absence of the lower portion of the trapezius muscle. The incision was vertical, along the lower half of the mesial border of the scapula. The periosteum was split and elevated. The portion of the scapula united to the vertebral transverse processes was separated. The lower corner of the scapula was drilled, and a gauze loop passed through by means of which the whole lateral or external portion was drawn downward, 3 or 4 cm. The detached portion with its vertebral attachments was then reunited to the lateral portion by wire sutures. A strip of fascia was passed through the drill hole in the inferior part of the scapula and employed to anchor it in place. Gymnastic exercise and medicomechanical treatment followed. In a short time after the operation, the arm could be elevated to the perpendicular position.

Congenital Dislocation of the Shoulder.—Coudray [6] reports two cases of luxation of the shoulder from arrested development or malformation, one in a child and one in an adult. The right arm in both cases was useless. In the child, the head of the humerus was nearly normal in shape. Massage and exercise were followed in the child by prompt and progressive improvement, so that the hand could soon be raised to the head. The malformations in the adult were too extensive to be influenced by this treatment.

Spina Bifida Occulta.—Von Finck [7] has made a study of spina bifida occulta based on dissection findings in cadavers of new-born infants and in older living patients. He divides the cases into two groups: (1) those in which the spinous processes are rudimentary or lacking, and (2) those in which there is a lack of closure of the arches. These clefts tend to ossify before or at puberty, so that rarely does any defect last beyond this age. The condition is much more common than is generally supposed, and 35 per cent. of those cases examined by the author showed signs of the lesion. The higher the defect, the more complete the cleft is likely to be, and the more severe are the symptoms. With the defects in arch closure in the upper vertebra, there often exists a fatty mass in the spinal canal. A foveola coccygea, hypertrichosis, pressure pain, club feet and scoliosis are the usual signs and

6. Coudray: Bull. de l'Acad. de med. **86**:262 (Nov. 15) 1921.
7. Von Finck: Ztschr. f. orthop. Chir. **42**:65, 1921

symptoms, and especially unfavorable is the prognosis of those cases in which a scar is found in the midst of the area of hypertrichosis. The author has collected forty-six cases in the corpses of the new-born.

Madelung's Deformity.—Brandes [8] has reexamined two cases of Madelung's deformity of the wrist which he had described ten years previously. The patients were sisters, and their father had suffered from the same condition. The curve and expansion of the radius and the obliquity of the epiphysis had increased. He believes the condition to be usually congenital and to consist of a disturbance of growth of the epiphyseal cartilage. This disturbance of growth he considers primary, and the bending of the radius secondary. There may be other cases presenting a somewhat similar picture which may be the result of late rickets, in which the torsion of the radial shaft and its ulnar concave bending are primary.

Congenital Luxation of the Patella.—Mouchet and Durand [9] report a case of bilateral congenital outward luxation of the patella successfully relieved by operation, in a boy of 10 years. They reconstructed the patellar apparatus by transplanting inward the tubercle of the tibia, after having drawn the patellar tendon and detached tubercle through a buttonhole in the anterior capsule of the knee joint.

Congenital Dislocation of the Hip.—Thomas [10] reviews the problems presented by this condition on the basis of forty-four cases observed in a weekly orthopedic clinic during a period of eleven years. He believes heredity to be an important factor. He strongly favors the manipulative method, recognizing the occasional necessity for open operation. The control of the cases in the first three or four years of life he considers of great importance, and, in the selection of cases, he believes Ridlon's rule is the safest to follow, namely, to exclude from attempts at manipulation all patients under 2, with shortening of less than 1 inch (2.5 cm.), and all patients over 5 with shortening of more than 2 inches (5 cm.). The success of the procedure depends, in Thomas' opinion, on (*a*) the control of the early years of the child's life; (*b*) the ability of the surgeon to interpret the relation of the hip joint structures by his fingers, and (*c*) great gentleness of manipulation. Severe tearing or stretching of the tissues and forcing of the head into the acetabulum to deepen it, Thomas believes, are responsible for the later deformation of the head and the arthritic changes which we now know are so common.

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8. Brandes: Ztschr. f. orthop. Chir. **42**:20, 1921

9. Mouchet and Durand: J. de chir. **18**:225 (Sept.) 1921.

10. Thomas, H. B.: Congenital Dislocation of the Hip, J. A. M. A. **78**:323 (Feb. 4) 1922.

Blencke [11] confirms the interesting observation of Schanz that, since the war, in the German clinics, there has been a marked decrease in the number of cases of congenital dislocation of the hip, and a marked increase in the number of cases of congenital clubfoot. Congenital dislocation of the hip occurs about seven times more frequently among girls than among boys, and congenital clubfoot is twice as common in boys as in girls. The increase in male births since the war is held responsible for these phenomena.

Clubfoot.—Hahn,[12] in discussing the etiology of equinovarus, has been impressed with the strong hereditary factor which Felsher estimated at 66.6 per cent., and with the large percentage of acquired types, varying, according to different observers, from 24 to 40 per cent., associated chiefly with inherited changes in the vertebrae, most commonly with spina bifida occulta. He also finds the condition twice as common in males as in females and a little more commonly bilateral than unilateral in the congenital cases.

Gaugele [13] reserves the employment of open operative procedures for the cure of clubfoot for those cases in which, after two or three thorough redressments in plaster, an obstinate adduction of the forefoot persists, especially adduction of the great toe. If, in these cases, the outer border of the foot is pressed upward, the great toe becomes plantar flexed and adducted. He believes this is due to the fact that since the outer border of the foot is longer in these cases than the inner, the base of the fifth metatarsal opposes any straightening of the outer convexity. In several cases, the author has removed the base of the fifth metatarsal and freshened the adjacent surface of the cuboid to obtain union. He has found it possible immediately to correct the foot after this procedure, the plaster being applied with the forefoot in strong abduction.

Congenital Flatfoot. Backward Luxation of the Fibula. Volkmann's Deformity of the Ankle.—Brandes [14] reports an instructive case of a 7 year old child with congenital flatfoot, in whom the fibula was well behind the tibia and the tendon of the peroneus brevis luxated forward over the external malleolus. A transplantation of the tibialis anticus into the sustentaculum tali, performed a year previously, had failed to correct the position. Brandes transplanted the peroneus longus into the scaphoid, lengthened the contracted and forward placed peroneus brevis, and, after shortening the Achilles tendon, transferred its insertion mesially. A year and a half later, the foot was overcorrected

11. Blencke: Zentralbl. f. Chir. **48**:1625 (Nov. 5) 1921.
12. Hahn: Ztschr. f. orthop. Chir. **42**:151, 1921
13. Gaugele: Arch. f. orthop. **19**:455, 1921.
14. Brandes: Ztschr. f. Orthop. Chir. **42**:38, 1921.

and the varus was increasing so steadily that it was necessary to redress the foot again, shorten and displace forward the peroneus brevis and transplant the extensor longus hallucis into the fifth metatarsal.

RICKETS, OSTEITIS FIBROSA, OSTEITIS DEFORMANS, ETC.

Rickets.—Cozzolino [15] well sums up the arguments against the theory that the absence of fat soluble vitamin A is the cause of rickets: (1) While cod liver oil helps to cure rickets, the improvement is never so rapid as is the change in infantile scurvy when food rich in vitamins is given. (2) Rickets may develop on any diet. (3) Rickets shows a tendency to spontaneous (?) cure, while infantile scurvy (a disease known to be due to lack of vitamins) almost certainly will cause death unless treated. (4) While cod liver oil will cure rickets, phosphorus alone will do the same. (5) In experimental work on animals, rickets may develop in an animal on a diet rich in vitamin if he is confined closely, while it may not develop in an animal at liberty, though on a diet free from vitamins. (6) Treatment with violet rays or heliotherapy cures rickets.

Dodds,[16] as a result of experimental work, finds that the urinary diastase and fat content are greatly increased. In seventeen cases of rickets, the mean was 154 diastatic units, the normal number being from 6 to 30. This diastatic power falls during convalescence. The fat in the feces he also finds increased in his series, representing 75 per cent., as compared with 20 per cent. in a series of nonrachitic children. Dodds maintains that these findings suggest a pancreatic lesion in rickets, and that, as a result, there is a poor production of fatty acids and, consequently, a poor absorption of calcium.

Hess [17] reviews the newer aspects of the rickets problem. In addition to the two well recognized factors of improper diet and lack of sunlight, rate of growth and pigmentation of the skin are important in the development of rickets. With a rickets producing diet, the disease will or will not develop, according to the dosage of light. Rats fed with this diet do not have rickets if the proper dosage of the mercury vapor lamp is given, or if phosphorus is administered. The pigmentation of the skin affects the potency of light. If groups of white and black rats are fed a rickets diet and given a quartz mercury light treatment, the white ones will not develop rickets, while the black ones will do so. The darker the skin, the more light is required to protect against rickets. The relative importance of these factors is not

15. Cozzolino: Pediatria **30**:97 (Feb. 1) 1922.

16. Dodds: Brit. M. J. **1**:511 (April 1) 1922.

17. Hess, A. F.: Newer Aspects of Rickets Problem, J. A. M. A. **78**:1177 (April 22) 1922.

yet satisfactorily understood. Experiments were carried out in a large institution for the care of children and in the laboratory which seem to indicate that the fat soluble vitamin is not the dominating factor. Animals deprived of it develop an osteoporosis, but not a true rickets. The examination of the blood of the infants revealed that clinical rickets may precede the decrease in the inorganic phosphates in the blood, which becomes lowered later as the signs seen in the roentgenograms appear. There is some factor which determines its level.

Hess,[18] working with Pappenheimer, has demonstrated that rachitic lesions which develop regularly in rats on a diet adequate in calcium, but low in phosphorus, were prevented by short exposures to direct sunlight. They calculated that this protection is equivalent to the addition of at least 75 mg. of phosphorus to the diet, in the form of basic potassium phosphate.

Powers, Park, Shipley, McCollum and Simmonds [19] have been able, in rats fed on a rickets producing diet, to protect them from the development of the disease by exposing them to the irradiation of a mercury vapor quartz lamp. It is possible to say also that such irradiations affect the whole organism and not the skeleton alone. There is a favorable effect on muscular development, storage of fat, growth of the hair, sexual development and reproductive power. As far as they have been able to discern, the effects of the irradiation from the mercury vapor quartz lamp in bringing about an efficient utilization of the substances which are directly or indirectly concerned with ossification and calcification, and in promoting general bodily vigor, are in no way different in respect to these matters from the action of cod liver oil or sunlight.

Huldschinsky [20] reports the clinical and roentgen-ray cure of a case of severe rickets in a child of 3 by eighteen exposures to soft roentgen rays in a period of two months. He does not advocate this somewhat dangerous method of therapy, when equally good results may be obtained from other harmless forms of light, rich in ultraviolet rays, but looks upon the results as experimentally important.

Shipley, Park, McCollum and Simmonds,[21] as a result of their experiments, have come to the conclusion that there are probably two forms of rickets. One is characterized by a normal or nearly normal

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18. Hess, A. F.; Unger, L. J., and Pappenheimer, A. M.: J. Biol. Chem. **50**:77 (Jan.) 1922.

19. Powers, Park, Shipley, McCollum and Simmonds: Bull. Johns Hopkins Hosp. **33**:125 (April) 1922.

20. Huldschinsky: Ztschr. f. orthop. Chir. **42**:240, 1922.

21. Shipley, P. G.; Park, E. A.; McCollum, E. V., and Simmonds, N.: Is There More Than One Kind of Rickets? Am. J. Dis. Child. **23**:91 (Feb.) 1922.

blood calcium and a low phosphorus (low phosphorus rickets), and the other by a normal or nearly normal blood phosphorus, but a low blood calcium (low calcium rickets). They suggest the possibility that there may be a true renal rickets, and that the rickets accompanying the alimentary anemias may represent a somewhat different kind of disturbance in metabolism from that which is present in the ordinary forms of the disease.

The same authors,[22] by feeding animals with a diet low in phosphorus and in an undetermined organic substance and relatively high in calcium, have uniformly noted a disappearance of calcium from the epiphyseal cartilages and the metaphyses, as seen in the roentgenograms. The reappearance of this provisional zone of calcification, after the addition of any substance to the rickets producing diet, constitutes a test for the calcium depositing value of their substance. For example, cod liver oil to the extent of 2 per cent. by weight of the diet causes this provisional zone of calcification to be reformed in five days; 0.4 per cent. of cod liver oil fails to cause this zone of calcification to appear, and 1 per cent. causes a less complete calcium deposition in five days than 2 per cent. This test may be utilized to determine the efficacy of any agent to heal the rachitic lesions.

Shipley [23] again emphasizes the fact that the normal calcium phosphate ratio in the blood is altered in rickets. The normal calcium content is from 9 to 11 mg. for each hundred cubic centimeters of blood; the normal phosphates are from 4 to 6 mg. for each hundred cubic centimeters. If the calcium falls below 5, there is tetany either latent or manifest; that is, in cases of rickets with latent tetany there is marked blood calcium reduction.

Jacobsen [24] reports excellent results following manual correction of rachitic deformities of the legs, after the application of a plaster cast to the entire limb. This cast is allowed to remain on from six to nine weeks, depending on the age of the child. He considers all active and sclerosing types to be suitable for this method. The correction often requires much force, and frequently slight infractions of the cortex occur. After correction, a new plaster cast is applied for four weeks and cod liver oil and phosphorus are administered. Massage is instituted, and the child is allowed to be up in two weeks more.

Osteitis Fibrosa.—Young and Cooperman,[25] after reporting a case of the generalized form of this disease in a colored woman of 21 (first

22. McCollum, E. V.; Simmonds, N.; Shipley, P. G., and Park, E. A.: J. Biol. Chem. **51**:41 (March) 1922.

23. Shipley: Paper read before Medical Society of State of New York. April, 1922.

24. Jacobsen: München. med. Wchnschr. **68**:920 (July 22) 1921.

25. Young, J. K., and Cooperman, M. B.: Ann. Surg. **75**:171 (Feb.) 1922.

case reported in this race), conclude that under the term osteitis fibrosa should be included benign bone cysts, giant-cell sarcoma of the epulis type, hemorrhagic osteomyelitis and the generalized form, or von Recklinghausen's disease. They consider that these conditions represent a pathologic entity characterized by metaplasias of bone. They believe that local osteitis fibrosa and benign bone cysts are dependent on trauma and that the generalized form must represent grave nutritional disturbances, possibly caused by endocrine dysfunction, chronic low grade infection and a faulty calcium metabolism.

Morton [26] has made a very complete report of a case of the generalized form in a man of 23, who had suffered from the disease for many years and who presented an extreme deformity of the right femur and lesions demonstrable by the roentgen rays in the skull, right humerus, radius and ulna, and both tibias and fibulas. Two osteotomies of the right femur were performed after a failure to correct the deformity by wedging a plaster-of-Paris bandage. The femur united well, and six months later, the patient was using his corrected leg freely.

Brittle Bones and Blue Sclerotics.—The association of blue sclerotics with brittle bones is said to have been first described by Eddowes in 1900. He suggested that the transparency of the sclera indicated a lack of quantity or quality of the fibrous tissue forming the framework of various organs of the body and probably explained the lack of spring and toughness in the bones. The importance of heredity has been repeatedly observed, and Alexander [27] reports a case of fragilitas ossium associated with blue sclerotics in four generations. Mallardi [28] also reports a case of fragilitas ossium (or osteopsathyrosis) in a child of 3, with seven recent fractures, which had occurred without pain and which healed promptly, leaving some swelling in the region of the break. There was present in his case also a striking degree of blue in the sclerotics.

"Marble Bones."—Schoenberg, in 1904, described a peculiar affection which has been termed "marble bones," consisting of increased calcium deposit in the bones and increased fragility. Schulze [29] reports the seventh case, with the result of a necropsy. This revealed marked overdeposition of calcium in the diaphysis, a narrowing of the marrow space, irregularities of the epiphyseal lines, and club-shaped disappearance of the diploe and narrowing of the canals for the vessels and nerves of the skull, which in his case explained the optic nerve atrophy. There were deposits of calcium in most of the organs.

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26. Morton, J. J.: Generalized Type of Osteitis Fibrosa Cystica, Arch. Surg. **4**:534 (May) 1922.
27. Alexander, J. B.: Brit. M. J. **1**:677 (April 29) 1922.
28. Mallardi: Pediatria **30**:75 (Jan. 15) 1922.
29. Schulze: Arch. f. klin. Chir. **118**:411 (Nov. 24) 1921.

TUBERCULOSIS

Tuberculosis of the Joints of the Upper Extremity.—Valtancoli [30] reviews the cases of tuberculous joint disease of the upper extremity which have been treated at the Istituto Rizzoli for the last twenty-one years, 1899-1920. There were eighty-six of these cases, a very small number when compared to the number of cases of tuberculous joint disease of the lower extremity. Only hospital ward cases are included, however, and many cases were ambulatory. Forty-one of the eighty-six cases were disease of the elbow, twenty-eight of the wrist, and seventeen of the shoulder. For the first eleven years of the period, the treatment had been largely surgical, consisting of total or partial resections. For the last ten years, it has been largely conservative, consisting of fixation and heliotherapy. The results of both forms of treatment were evidently good; but it is interesting to know that conservative treatment has largely replaced the operative in this important institution where such able surgeons as Codivilla and his successor Putti have been responsible for the care of patients.

Tuberculous Tenosynovitis of the Hand.—Kanavel,[31] at the meeting of the Western Surgical Association, called attention to the fact that tuberculosis of the tendon sheaths of the hand may occur in both the dorsal and palmar groups. An early diagnosis, based on the suggestive fulness over the sheaths, the slight stiffness of the fingers, and the inability to flex or extend them completely, is of great importance. If one waits before operating until rupture has taken place or there has been a destruction of the tendon which will ensue if the process is long continued, the results are likely to be unsatisfactory. The operation should be thorough, completely removing all tuberculous tissue, even including the tendon if necessary, in which case a plastic operation will be required to restore function.

Exner [32] describes a case of tuberculosis of the palmar fascia closely resembling Dupuytren's contracture in a girl, aged 20 years. The disease tissue was excised. This showed tuberculous granulations, a little caseous material and a marked tendency to the formation of connective tissue.

Vertebral Tuberculosis, Pott's Disease.—Matheis,[33] on the basis of twenty cases of tuberculous spondylitis in adults treated since 1919, considers the result of conservative treatment to be discouraging and the result of treatment by the bone graft method much better. He

30. Valtancoli: Chir. d. org. di movimento **5**:652 (Dec.) 1921.

31. Kanavel, A. B.: Tuberculous Tenosynovitis of the Hand, abstr. J. A. M. A. **78**:304 (Jan. 28) 1922.

32. Exner: Wien. klin. Wchnschr. **34**:252 (May 26) 1921.

33. Matheis: Wien. klin. Wchnschr. **34**:557 (Nov. 17) 1921.

believes the operation is advisable only in adults, since in children we may expect an ankylosis from conservative treatment, and the length of time taken for a cure is not a serious matter. His conclusions are similar to those of Baer,[34] who reports the results of fifty operations by the Albee method, performed at least two years previous to the report. Those patients operated on during the period of growth showed less than 33 per cent. of good results. Those operated on after 16 showed 90 per cent. of good results. All of the grafts in the cervical region showed poor results. The longer the duration of the disease before the operation, the better the results; but the greater the kyphosis at the time of operation, the least likelihood of cure. He believes artificial support is necessary for at least six months after the operation in adults and for from two and one-half to three years in children. His conclusions are that in infancy the operation is of questionable value; that it may be of value in carefully selected cases in the growing period of 6 to 16 years, but must be considered only as an aid to proper mechanical treatment; that in adults the operation is indicated in the majority of cases, but that mechanical support should be employed for at least six months after the operation.

Cofield[35] calls attention to hypertrophic bone changes which take place in a certain number of cases of tuberculous spondylitis during the active stage of the disease. He has demonstrated these changes in ten out of 100 cases which he has studied. These changes he looks upon as nature's attempt to ankylose the diseased area by means of bony bridges. It seems to be peculiar to the adult form, and Cofield considers that it suggests the essential soundness of the principle of operative fixation by means of a fusion operation or a bone graft.

Multiple Foci in Tuberculous Spondylitis.—Peabody,[36] in an examination of 312 roentgenograms of tuberculosis of the spine, discovered thirteen in which there was more than one separate focus of disease. Since many of the cases showed only the area of suspected disease, Peabody believes the actual percentage to be higher than this 4 per cent., perhaps as high as 8 per cent.

Wimberger[37] also reports a case of a boy with a healed process involving the second and third lumbar vertebrae and an active process in the seventh, eighth and ninth dorsal vertebrae.

[ED. NOTE.—These cases are instructive and the Editors have met several in which two separate areas of disease existed, one of which was unsuspected at the time an ankylosing operation on the more active

34. Baer, W. S.: Bull. Johns Hopkins Hosp. **33**:140 (April) 1922.
35. Cofield, R. B.: J. Bone & Joint Surg. **4**:332 (April) 1922.
36. Peabody, C. W.: Ann. Surg. **75**:95 (Jan.) 1922.
37. Wimberger: Wien. klin. Wchnschr. **35**:102 (Feb. 2) 1922.

focus was performed, but which became active later and required a second ankylosing operation. It is evidently important, before subjecting the patient to an operation, to study carefully roentgenograms of the entire spine in the search for unsuspected early or inactive areas of disease.]

Diagnosis of Early Hip Joint Disease.—Rugh [38] considers the most important indications of early tuberculous hip joint disease to be: (1) the history; (2) the intermittent limp; (3) the muscular spasm; (4) the limitation of motion in all directions; (5) the position of the limb, i. e., apparent shortening or lengthening due to permanent abduction, adduction or flexion; (6) the atrophy of the muscles; (7) the referred pains, to the knee especially; (8) the night cries; (9) the slight elevation of temperature, and (10) the roentgen-ray findings.

Rugh says that the conditions most likely to be mistaken for tuberculous coxitis are: (1) rheumatism; (2) growing pains; (3) synovitis; (4) genital irritation; (5) epiphysitis; (6) acute rickets; (7) infantile scurvy; (8) contraction of the psoas muscle; (9) disease of the spine or knee; (10) coxa vara and coxa plana or Legg, Calvé, Perthes' disease.

[Ed. Note.—If under the term rheumatism, Rugh includes those very frequent cases of hip joint pain and limitation of motion which arise from digestive upsets and intestinal absorption, we should agree in placing this first in his list of conditions which closely resemble early tuberculous coxitis. In fact, it is our experience that often one cannot make a positive diagnosis in a case of this sort at the first visit. They may present an inconclusive history, an intermittent limp, muscle spasm, limitation of motion in all directions, abduction, adduction and flexion, referred pains, night cries, slight elevation of temperature. Early tuberculous coxitis may show little or no muscular atrophy and inconclusive roentgenologic findings, as do these cases. We believe this train of hip joint symptoms from intestinal infections or absorption of toxins are comparatively common. We see more cases of these fleeting disturbances than of true tuberculous coxitis. They are easily mistaken for the more serious condition, but they seem to demand only freedom from weight bearing and thorough evacuation of the bowels by means of abdominal massage, laxatives, and sometimes even enemas, after which the symptoms disappear very quickly, to be repeated if the intestines again become clogged. The absence of atrophy and the rather sudden, though often painless, onset of the limp and joint motion limitation should make us suspect this nontuberculous coxitis and refrain from too completely fixing the joint and unduly alarming the parents. In these doubtful cases, it is safer to insist on recumbency, and, while the symp-

38. Rugh, J. T.: New York M. J. **115**:256 (March 1) 1922.

toms exist, treat the case as if it were the more serious condition, but surely not condemn the child to permanent fixative treatment until we are sure of the diagnosis.

Excision of Os Calcis for Tuberculous Osteitis.—Wakeley [39] reports the late result of a complete excision of the os calcis for tuberculosis. The operation was performed twenty-one years ago when the patient was 20 years old, and he can walk several miles without discomfort or limp. The heel has filled up with a large pad of fat.

Diagnosis in Tuberculosis of Bones and Joints.—Kisch [40] has written a useful paper dealing with the frequent blunders that are made in the diagnosis of tuberculosis of the bones and joints. He points out that a patient with a gonococcal joint will usually remember the day of onset and describe more pain than will a patient with a tuberculous joint. The roentgenogram of a tuberculous joint will show trabeculae more clearly than a gonococcal joint, in which they are less distinct and the shadow more hazy. A sternoclavicular joint disease is more often syphilitic than tuberculous. A flocculent exudate on aspiration speaks for tuberculosis rather than a syphilitic or gonococcal effusion. The most conclusive evidence is obtained by animal inoculation of the exudate.

Treatment of Bone and Joint Tuberculosis by Injections of Tubercle Bacilli Split Products.—Joannovics showed that split products of tubercle bacilli fermentatively obtained had the property of disorganizing, breaking down and attacking injured tissue. In animal experimentation, they caused a production of normal granulation tissue by their effect on the diseased granulation tissue. Stracker [41] has employed injections of these products to the limit of reaction, every second day, for two months. Tenderness and pain on motion disappeared, except in the severe cases, but no rapid or complete disappearance of symptoms occurred. At first there seemed to be an increase in the discharge from sinus cases. He realizes that his experience is too short and limited to be conclusive; but he believes he has demonstrated at least that no very rapid cures may be expected and he questions whether, in his healed cases, the element of time was not more important than the specific medication.

SYPHILIS

Bone Changes in Congenital Syphilis.—Dembo, Litchfield and Foote,[42] writing on the foregoing subject, consider the diagnosis a comparatively

39. Wakeley, C. P. G.: Brit. J. Surg. **9**:553 (April) 1922.

40. Kisch: Arch. f. klin. Chir. **118**:481 (Nov. 24) 1921.

41. Stracker: Wien. klin. Wchnschr. **34**:569 (Nov. 24) 1921.

42. Dembo, L. H.; Litchfield, H. R., and Foote, J. A.: Bone and Joint Changes in Congenital Syphilis, J. A. M. A. **78**:319 (Feb. 4) 1922.

easy one to make if the history is carefully obtained from the mother and search made for other manifestations of the disease, in which search the roentgen ray is of special value. The Wassermann reaction is of marked positive, but less negative, value. Syphilitic epiphysitis is often of very acute onset, with swelling, tenderness and pain. Syphilitic dactylitis is usually multiple, while tuberculosis involves ordinarily one finger alone and the first phalanx of the index finger is its most common seat.

Among forty-three infants suffering from inherited syphilis, Thoenes [43] found the distal epiphyses of the ulna and radius were the favorite spots for localization of the syphilitic changes; but they were not completely symmetrical. He noticed also that roentgenograms seemed to reveal more severe bone lesions in cases free from cutaneous signs of the disease.

Skinner,[44] in an article on the roentgenology of bone syphilis, comments on the fact that the roentgen-ray records are rarely paralleled by the clinical symptoms. The lesions shown by the roentgenograms are much more extensive than the clinical findings. He calls attention to the fact that the essential process in bone syphilis is constructive.

PARALYSIS

Value of Colloidal Gold Reaction in Acute Epidemic Poliomyelitis.—Regan and Cheney [45] made the colloidal gold test of seventy-four specimens of spinal fluid obtained from twenty-one cases of acute epidemic poliomyelitis. The fluids were examined at intervals varying from the fourth to the one hundred and twenty-third day of the disease. The predominant type was the myelitic, most of the cases presenting symptoms of moderate or marked polyneuritis. The authors are fairly well convinced that a relationship exists between the duration of the positive colloidal gold curve and the acute inflammatory stage of the malady. They have been led to believe that when the reduction of the gold chlorid becomes normal, the acute period of the disease is over. If this is so, the reaction may well be of value as an index of the appropriate time for passing from the treatment of complete rest to the more energetic physiotherapy. They have noted also that, with the gradual subsidence of the colloidal gold curve, there is usually a corresponding improvement in the patient's general condition and in his paralytic and meningeal symptoms. No close relationship was found between the cytology and chemistry of the spinal fluid and the gold

43. Thoenes: Arch. f. Kinderh. **70**:252 (Jan. 28) 1922.

44. Skinner, E. H.: Am. J. Syphilis **6**:58 (Jan.) 1922.

45. Regan, J. C., and Cheney, G. W. H.: Am. J. Dis. Child. **23**:107 (Feb.) 1922.

chlorid reaction. The chemistry and cytology of the spinal fluid seems to return to normal almost as soon as the acute symptoms have subsided, while the gold chlorid curve returns to normal more slowly, remaining elevated usually after other pathologic signs in the spinal fluid have disappeared. The colloidal gold test proved in their hands of no special prognostic value in the fatal cases. It was usually more marked, but did not differ sufficiently in the first few weeks from the nonfatal acute cases to be helpful.

Poliomyelitis with Cortical Involvement.—Clark,[46] in an analysis of thousands of cases of epilepsy, has encountered only three in which poliomyelitis has been followed by enduring epilepsy. A disposition of the epileptic type was present in all of these three before the attack of poliomyelitis, one of them being a typical epileptic in temperament and mental makeup. Clark believes that the predisposition to the disease existed before the paralytic attack. He can offer no surmise as to what the meningeal or cortical lesion coincident with the poliomyelitis represents.

Poliomyelitis and Epidemic Encephalitis.—Cadwalader [47] states that clinical phenomena presented by certain nonparalytic cases of acute poliomyelitis, influenza and epidemic (lethargic) encephalitis are so similar that one must depend largely on the knowledge as to whether an epidemic of one or the other is prevalent. In poliomyelitis, the seventh cranial nerve is most often affected, while in epidemic encephalitis the third nerve is commonly involved. The author considers epidemic (lethargic) encephalitis an infectious disease possessing a separate and distinct entity. It differs from poliomyelitis particularly in the long survival of the virus in the central nervous system. Its course, therefore, may be very irregular and exhibit remissions and exacerbations extending over months or years. The diagnosis between the two conditions, however, will often be impossible if only the subjective and objective signs are considered.

Paralysis from Section of Spinal Cord.—Lhermitte and Pagniez [48] report the case of a child of 13 who sustained a complete section of the spinal cord in the dorsal region from a severe trauma at the age of 3. Although there was complete paralysis of the lower limbs, their normal growth had not been materially altered. They conclude that the sympathetic nervous system must largely control growth and regeneration of tissues, and that this case offers a strong argument against the existence of trophic cerebrospinal centers.

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46. Clark, L. P.: New York M. J. **115**:131 (Feb. 1) 1922.
47. Cadwalader, W. B.: Am. J. M. Sc. **162**:872 (Dec.) 1921.
48. Lhermitte and Pagniez: Presse méd. **30**:57 (Dec. 21) 1922.

ARTHRITIS

Chronic Infectious Arthritis.—Billings, Coleman and Hibbs [49] have studied the end-results of treatment of 411 cases of chronic arthritis. They consider that their investigation confirms the view held by a majority of clinicians that chronic deforming arthritis is primarily an infectious disease and that the micro-organisms which are most commonly responsible are strains of nonhemolytic streptococci of relatively low virulence, and less often strains of nonpyogenic gonococci and other bacteria of low pathogenicity. In 50 per cent. of their cases, the tonsils seemed to be the probable foci of infection, and the embolic mode of infection caused the tissue reactions, proliferative, hypertrophic, atrophic or degenerative. General chronic infectious myositis with only slight joint involvement in the early stage of the disease was a clinical entity in the group studied. The more acute the onset, the more favorable the prognosis proved to be. Of a group of 133 patients admitted within two years after the onset, 31.5 per cent. recovered and 27 per cent. were improved. Of 278, whose disease started more than two years before admission, only 10.4 per cent. recovered and 38.1 per cent. were improved. Of 229 patients who received vaccines, 17 per cent. recovered and 38.9 per cent. improved. Of 164 who did not receive vaccines, 17 per cent. also recovered and 28 per cent. improved. They consider treatment by vaccines to be of little value. Of 186 patients who carried out physical therapy thoroughly, 32 per cent. recovered and 61 per cent. improved. The authors are convinced of the importance of the avoidance of fatigue, and also of the value of daily physical exercise and hydrotherapy.

[Ed. Note.—Such an extensive review by eminent internists of cases of this baffling disease is of great value. It makes it evident that we as yet have no rapid method of cure in the majority of cases and that we must always first search for a surgical focus. It is also clear that the finding of a probable focus and its eradication may not, unaided by other methods of therapy, result in a rapid cure of the disease, or even, in many instances, in a satisfactory improvement. The lines along which this improvement and eventual cure must apparently be sought are, as the authors suggest, general physiotherapeutic lines, heliotherapy, massage and exercise. We are convinced that the absorptive and eliminative functions of the intestinal canal are from the start intimately connected with the solution of the problem, and that, therefore, the question of diet is of great importance. Painstaking studies of diet and blood gases along biochemical lines, which have been made and are being made by Pemberton and others, have helped, and, we

49. Billings, F.; Coleman, G. H., and Hibbs, W. G.: Chronic Infectious Arthritis, J. A. M. A. **78**:1097 (April 15) 1922.

believe, will continue to help, toward the solution. It is also evident that the attempts of Goldthwait, Swaim and others to improve the bodily mechanics of these chronic sufferers have been attended with much success in restoring function and apparently arresting the course of the disease. We will call attention here to a review of Dr. Percy Wilde's book, which concludes this section, advancing a different theory for the cause of chronic arthritis. The report of a personal observation of Wilde's work and results indicates that more attention should be paid to his theories and methods than they have received in this country.]

Autoserotherapy in Arthritis.—Dufour, Thiers and Alexewsky [50] add three new cases to their previously reported three, in which what they consider as rapid cures of arthritis have resulted from subcutaneous injections of fluid obtained by aspiration of an affected joint. They inject from 10 to 20 c.c., repeating this injection as often as aspiration is required. They have found the method harmless, even when the fluid contains pus or gonococci. Their six patients have recovered in from four to thirty days, and in seven similar cases published by other authors, the results have been equally successful.

Dental Foci.—Lurie [51] emphasizes the importance of not being satisfied with mere tooth extraction in the attempt to remove possible foci at the roots of the teeth. A granuloma, a cyst or an apical abscess may be left behind. He advises opening the alveolus under local anesthesia and dissecting out the root, really removing the surrounding source of infection. He reports two cases of sciatica relieved in two or three days after such complete removal of dental foci. One of these cases was of four weeks' and the other of six weeks' duration. Salycilates, medical baths, and a belt had failed to relieve, and one of the patients had had simple extraction of the teeth previously without benefit.

BOOK REVIEW

THE PHYSIOLOGY OF GOUT, RHEUMATISM AND ARTHRITIS AS A GUIDE TO ACCURATE DIAGNOSIS AND EFFICIENT TREATMENT. By Percy Wilde. Cloth, $3.50. Pp. 229, with 31 illustrations. New York: William Wood & Co., 1922.

The author's enthusiasm for his subject is infectious and his presentation admirable. He believes that arthritis is not a definite disease, but an expression of faulty physiology. His experiments have convinced him that certain of the chemical technics previously employed have been faulty, and that, for instance, in estimating the quantity of uric acid, the only nitrogenous product in the solution has been added by the chemist himself in the course of his experiment. He holds that the production and elimination of lactic acid and the so-called lactic acid diathesis are of great importance. The application

50. Dufour, Thiers and Alexewsky: Bull. et mém. Soc. méd. d. hôp. de Paris **45**:1558 (Nov. 25) 1921.

51. Lurie, W. A.: New Orleans M. & S. J. **74**:622 (March) 1922.

of physiologic theories to the treatment of the various forms of rheumatism and gout is most interesting and suggestive. If he rides his hobby a bit hard and perhaps attempts to explain too many conditions, it is none the less the hobby of a very observant man who has not been satisfied with the long established methods of investigation and treatment and has attempted to work out a more rational physiology.

Simultaneous Hydrops of the Knees.—Under the title "Simultaneous Hydrops of the Knees," Fitz-Simmons [52] discusses thirteen cases of bilateral knee joint effusion observed at the Children's Hospital, Boston. After a careful study of these cases, the etiologic factor was discovered to be tuberculosis in four; positively syphilitic in four, and an infection, neither tuberculous nor syphilitic, in two. In the tuberculous joints, pain was an earlier and more constant symptom. Fever was more common and the constitutional symptoms of general weakness and tire were more marked than in the syphilitic group. Surface temperature, bony thickening, limitation of motion and a more rapidly destructive process were more characteristic of the tuberculous joints than of the syphilitic. Symmetrical synovitis of the knee joints in a child, chronic in nature, free from marked symptoms of pain even on motion, strongly suggests hereditary syphilis. In these joints, an excellent functional result may be expected.

Injection of Ether in Chronic Hydrarthrosis.—Rocher [53] has practiced, for more than a year, injection of sulphuric ether into joints affected with chronic hydrarthrosis, presumably of unknown etiology. The injected ether is squeezed into all parts of the synovial cavity, which should be under slight tension from the injected fluid. The fluid is then quickly withdrawn. A compression bandage is applied. There is moderate pain followed by anesthesia, but some pain and swelling persist for twenty-four hours. He reports a case of four years' duration relieved in five days.

Intermittent Hydrops.—Nielson [54] reports a fairly typical case of irregular intermittent hydrops, on which two arthrotomies were performed with no permanent relief, the attacks later on occurring regularly, from every ten to eleven days.

[ED. NOTE.—This experience is in keeping with that of the Editors. In the cases observed by them, improvement of posture, foot strain and general bodily mechanics have in several instances been associated with a lessened frequency and severity of the attacks, and in one case therapeutic administration of roentgen rays, every three weeks for a

52. Fitz-Simmons, H. J.: J. Bone & Joint Surg. **4**:376 (April) 1922.
53. Rocher, H. L.: Presse méd. **30**:256 (Feb. 15) 1922.
54. Nielson, A. L.: Intermittent Hydrarthrosis, J. A. M. A. **78**:507 (Feb. 18) 1922.

period of two months, in addition to this correction of bodily mechanics, has been followed by a subsidence of attacks, which has lasted for six months and is still continuing.]

Juvenile Deforming Osteochondritis of the Hip Joint, Pseudocoxalgia, Coxa Plana, Legg, Calvé, Perthes Disease.—Lance,[55] reporting seventeen cases of this condition, has been impressed with the fact that an hereditary history could be established in many of the cases. He believes that other infections may be responsible, but that, in the syphilitic cases, medication has materially modified the disease, a complete restitution having been realized in some of the cases.

Platt [56] has written a thesis under the title "Pseudocoxalgia," which very completely covers the subject. His conclusions, based on the close observation of a large number of cases, are as follows: (1) Pseudocoxalgia, or osteochondritis deformans juvenilis, is a definite entity, representing the reaction of the metaphyseal region of the upper end of the femur to the stimulus of an infective agent of attenuated virulence. (2) The condition is comparable to arthritis deformans juvenilis coxae, which is seen solely in adolescents and represents at this age the reaction of the hip joint to an infective agent of similar type. (3) In the conditions known as tarsal scaphoiditis (Köhler's disease), apophysitis of the tibial tubercle (Osgood-Schlatter's disease), bony changes parallel to those in pseudocoxalgia are found. (4) Conservative treatment directed toward the elimination of weight bearing has no proved influence on the train of morbid symptoms; but its application is indicated during the stage of prominent symptoms. Operative treatment directed toward the removal of the dominant lesion has no place in the therapy of the disease at present.

NEOPLASMS

Cysts in Bone.—Mouchet and Le Gac [57] are convinced from a study of their cases that trauma plays an unimportant rôle in the etiology of simple bone cysts. Trauma, on the other hand, often results in a cure of the condition, allowing the fluid to escape, which is followed by periosteal repair. Immobilization in these cases is all that is required. When cysts of the large long bones are discovered, they should be trephined and curetted, but not filled or drained, since they are sterile and benign.

Myxoma of the Knee.—Bolognesi [58] reports a case of pure myxoma occurring in a knee joint. The lesion resembled very closely a fungus type of tuberculosis.

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55. Lance, Andrieu and Capellè: J. de chir. **18**:471 (Nov.) 1921.
56. Platt: Brit. J. Surg. **9**:366 (Jan.) 1922.
57. Mouchet and Le Gac: Arch. franco-belges de chir. **25**:337 (Jan.) 1922.
58. Bolognesi: Chir. d. org. di movimento **6**:17 (Feb.) 1922 .

Metastatic Carcinoma of Bone.—Catsaras [59] has found one case in the literature of metastatic carcinoma of bone from a primary focus in the liver. In a second case which he reports, the head and neck of the femur were invaded by an adenocarcinomatous metastasis from the liver, the tumor cells in the femur being deep green in color, with abundant production of bile.

Oppenheimer [60] has analyzed thirty-two cases of spinal cancer seen at the Montefiore Hospital in New York. The breasts were the primary seat in 66 per cent. of the cases, the lung and thyroid being the next most common sources of origin. Three of the patients had had breast operation at least eight years previously without local recurrences. In seven of the cases, the first indication of the spinal lesion was fracture following slight trauma, pain having been absent before the fracture. In nineteen, however, pain had been a prominent symptom, and ten patients had pain on local pressure. In fifteen, pain in the lower extremities was present, and in thirteen this was an early symptom. Deformity was present in fourteen cases. The roentgenologic findings were positive in only fifteen cases. Fifteen patients had no symptoms referable to the central nervous system. The writer believes that it is possible to foretell the ultimate vertebral breakdown long before it occurs. The most typical change is slight dislocation forward, so that there appears a more or less definite recession of one or more spinous processes. Slight lateral displacements are also not uncommon.

Sarcoma.—Valentin [61] adds one more to Stern's compilation of twenty cases of sarcoma of the os calcis. The symptoms dated back six or seven years, and histologic examination of the tissue, removed in a piecemeal extirpation, demonstrated it to be of the epulis type. Valentin considers cutaneous venous dilatation, with an otherwise normal skin, to be an important sign of neoplasm of the tarsus.

Meyerding [62] has made a study of 109 patients operated on at the Mayo Clinic, whose cases were proved to be sarcoma by pathologic examination. From 1907 to 1921, 470 cases were diagnosed as sarcoma of the extremities. Thirty-five per cent. of these patients were considered to be inoperable or refused operation. Thirty-two of the thirty-five patients who underwent an amputation died subsequently. The average duration of the disease at the time of operation was seven and thirty-four hundredths months and the average length of life following the operation in those who died was fourteen and five-tenths months. The most malignant of the series were the osteosarcomas (probably

59. Catsaras: Ann. de méd. **10**:295 (Oct.) 1921.
60. Oppenheimer, E. D.: J. Bone & Joint Surg. **4**:342 (April) 1922.
61. Valentin: Klin. Wchnschr. **1**:24 (Jan. 1) 1922.
62. Meyerding, H. W.: Surg., Gynec. & Obst. **34**:321 (March) 1922.

the osteogenic type of Ewing, which will be reported later). Meyerding believes that if any doubt exists as to the nature of the tumor, an exploratory operation and a microscopic examination of the tissue are demanded before resorting to radical operation. The principal points to be determined before operation are the question of malignancy, the existence of metastases and the extent of bony involvement.

Ashhurst,[63] opening the discussion on sarcoma at the Philadelphia meeting of the American College of Surgeons, said that the pathogenesis of sarcoma must for the moment be left unsettled. In general, he urges the conservative treatment, and, in disagreement with Ewing (see next review), believes that excision of a portion of the tumor for microscopic examination is a harmless procedure and likely to save a life or limb. He considers that Coley's mixed toxins deserve a trial in all forms of bone sarcoma. The true value of radium has, in his opinion, not been determined.

Ewing[64] holds that a classification of bone tumors must not be made from the constituent cells they contain or from the possible origin of these cells. The classification must be both clinical and anatomic. The classification which he suggests is as follows:

Osteoma	Spongy Ivory	
Chondroma	Pure chondroma Chondromyxoma Myxoma	Capsular Periosteal Central
Angioma:	Cavernous	
Endothelioma	Angio-endothelioma Diffuse	Solitary Multiple
Benign Central Giant-Cell Tumor and Its Variations	1. Bone cyst 2. Giant-cell tumor 3. Xanthosarcoma 4. Myxosarcoma (benign)	
Osteogenic Sarcoma	Periosteal (extraperiosteal) Solid medullary and subperiosteal Telangiectatic Sclerosing	
Myeloma	Plasma cell Lymphocytic Myelocytic Erythroblastic	

In regard to prognosis and treatment of sarcomas of bone, he is very much opposed to diagnostic incisions as he believes that careful history, roentgen-ray findings, and the results of the therapeutic test with roentgen rays or radium are of much more value than the examination of a small isolated section of tissue which may not be in the right part of the tumor and which may go to a pathologist who is not

63. Ashhurst, A. P. C.: Surg., Gynec. & Obst. **34**:333 (March) 1922.

64. Ewing, James: Review and Classification of Bone Sarcomas, Arch. Surg. **4**:485 (May) 1922.

conversant with bone tumors. Ewing believes that the nonoperative treatment is the goal to be aimed at. The vast majority of bone sarcomas of every type give highly characteristic roentgenograms, which, interpreted in the light of exact and simple clinical data, permit a reasonably accurate diagnosis. Ewing lays emphasis on the following roentgenologic details: Osteogenic sarcoma almost never affects the middle half of the shaft, but is a disease of the diaphyseal ends. Erosion or destruction of a segment of the shaft is nearly constant in osteogenic sarcoma. The benign central tumors regularly widen the shaft and displace the periosteum with its thin shell of bone, long before more aggressive forms of this disease invade the soft tissue. Myelomas and diffuse endotheliomas involve wide segments of the bone, often the midportions, and cause smooth gradual fading of the shaft. Syphilis, tuberculosis, chronic osteomyelitis and periostitis, Paget's disease, each presents its own peculiar morphology and clinical setting, and, with rare exceptions, lack the specific features of bone tumors. But he goes on to say that the interpretations require experience.

The therapeutic test is the decisive evidence between certain classes of bone tumors. Myelomas and diffuse endotheliomas melt down rapidly under roentgen ray and radium. These physical agents control the growth of the benign central tumors and cause the gradual restoration of the shaft, while the relief of pain is usually prompt. With osteogenic sarcoma, roentgen ray and radium have little or no immediate effect on the size or form of the tumor. Chondromas seem to be wholly unaffected by external irradiation.

Ewing gives the following scheme to secure more accurate data regarding the prognosis of osteogenic sarcoma: (1) encapsulated extraperiosteal fibrosarcoma; fibrous, cartilaginous or osteoid stroma in excess of cells; prognosis, fair; (2) sclerosing medullary and periosteal sarcoma; course very slow; metastases appear very late; (3) cellular spindle cell periosteal sarcoma, stroma scanty or absent; some cures by surgery and other methods; (4) solid cellular central and subperiosteal sarcoma; some surgical cures of early cases; (5) very vascular cellular telangiectatic sarcoma; no reported cures.

Codman [65] explains the working and future plans of the Registry of Cases of Bone Sarcoma and asks the cooperation of all surgeons. He discusses the nomenclature as used by the Registry, which is practically that of Ewing. Osteogenic means derived from bone forming tissue and osteogenetic means a bone forming tissue. Benign giant-cell tumors should be the term employed instead of giant-cell sarcoma. The cases thus far registered fall into four groups: (1) malignant osteogenic sarcoma; (2) benign giant-cell tumors; (3) rare forms of primary bone tumors; (4) errors in diagnosis.

65. Codman, E. A.: Surg., Gynec. & Obst. **34**:335 (March) 1922.

The Registry has had correspondence concerning, or has actually observed, 454 cases. Of this number, it has been obliged to exclude, for lack of roentgen-ray examination, or lack of microscopic section and gross tissue, or because the diagnosis was obviously incorrect, 317 cases. There remained forty-one cases of osteogenic sarcoma, forty-three cases of giant-cell tumor and fifty-three cases were considered undetermined. In only five cases of osteogenic sarcoma are the patients known to be alive five years after the operation.

[ED. NOTE.—Codman and his associates have done much to awaken medical interest in this perplexing subject of bone sarcoma. The foregoing reviews will indicate how much there remains to be learned concerning this form of malignant and nonmalignant bone invasion. If American surgeons will cooperate, the Registry is sure to add to our knowledge and unify our terminology.]

OSTEOMYELITIS

Acute Osteomyelitis.—Cohn [66] emphasizes the importance of early recognition of acute osteomyelitis if sequestration is to be prevented. He is convinced that it is a blood-borne disease, localized primarily in the medullary canal. There are no early roentgen-ray findings on which a diagnosis can be based, and the early operative findings may be only of fat necrosis of the medullary canal without frank pus. Early operation should give almost instant relief from pain, cause a subsidence of temperature, prevent the formation of sequestrums, and bring about a complete restoration of function. Cohn advises opening the medulla, preferably with motor driven instruments, even if pus is found beneath the periosteum, feeling sure that the infection has reached the cortex through the haversian system. The use of the curet is decried.

Starr,[67] in an article on acute hematogenous osteomyelitis, also considers the disease blood-borne from a focus situated elsewhere in the body. The disease occurs most frequently between 2 and 10 years. Trauma is a distinct factor, and boys are slightly more frequently affected than girls. Severe pain in the neighborhood of a joint with a spot of tenderness in a growing child is extremely significant. If this is accompanied by a high fever, rapid pulse and a high leukocyte count, the diagnosis is fairly certain. The roentgen ray is of no assistance in early diagnosis and it is essential that an early diagnosis be made. The treatment should consist of an incision over the area of greatest tenderness, continued through the skin, subcutaneous tissue and periosteum. Care should be taken to keep the incision on the diaphyseal side of the epiphyseal line and to preserve the periosteal

66. Cohn: New Orleans M. & S. J. **74**:505 (Jan.) 1922.

67. Starr, C. L.: Acute Hematogenous Osteomyelitis, Arch. Surg. **4**:567 (May) 1922.

attachment to the epiphyseal line, thus safeguarding, to a large extent, the danger of extension to the joint. If frank pus is encountered, Starr, in disagreement with Cohn, considers this incision sufficient, a drain being inserted. If no gross pus is found, the periosteum is stripped for a short distance on either side of the incision, to make sure that the incision is in the right plane, and if no frank pus is seen, a series of drill holes, usually three, is made about one-fourth inch apart downward, toward, but not into, the epiphysis, extending into the center of the shaft. Starr says that in no case has he opened the medullary cavity. He considers it a dangerous procedure. When a case is seen in the later stages, efficient drainage should be established, but the definite operation is delayed until the sequestrum is separated. Then a channel is chiseled of sufficient size to allow the removal of the sequestrum through the involucrum. The cavity is cleaned of dirty granulation, sponged with iodin and packed tightly with iodoform gauze for forty-eight hours. After the packing and drains are removed, and if the remaining cavity is too large to fill easily with granulation, the edges are made saucer-shaped and the soft tissues and periosteum allowed to fall in and obliterate it.

[ED. NOTE.—The difference between Starr's working rule and Cohn's is an essential difference. We take it Starr is discussing osteomyelitis in the immediate neighborhood of a joint. Cohn believes the cortex should always be drilled, whether frank pus is or is not encountered beneath the periosteum. Starr does not drill the bone if he finds gross pus beneath the periosteum. Starr's experience as child surgeon of the Sick Children's Hospital in Toronto has been a very long and broad one, and he follows his cases carefully. If he was obliged to open the shaft later in any considerable number of cases in which he encountered frank pus beneath the periosteum, or if the majority of these patients did not, in his opinion, do well, he would not give conservative advice. On the other hand, if in any case of osteomyelitis the infection was, in the early stage, limited to the exterior of the shaft and between it and the periosteum, it would be most unwise, after having provided drainage at the seat of the infection, to drill into an uninfected shaft and perhaps carry the infection farther.]

Epiphysitis of the Femur.—Dickson [68] lays especial stress on the importance of differentiating between tuberculosis and pseudocoxalgia, both of which have a slow onset, and pyogenic epiphysitis of the hip, which has an acute onset, high fever and extreme pain. For the latter condition, immediate operation is required, which may well be only that of drainage as an initial procedure; a later operation when the

68. Dickson, F. D.: J. Missouri M. A. **19**:16 (Jan.) 1922.

child's general condition has improved, consisting of cleaning out of the necrotic material and instituting an attempt to sterilize the wound with surgical solution of chlorinated soda. Traction is maintained throughout the course of the treatment.

Osteomyelitis from Colon Bacillus.—Satta [69] reports a case of putrefying, gangrenous osteomyelitis following a compound fracture of the leg. After five months, healing had occurred; but two months later, the leg again became swollen, and at operation a pure culture of colon bacillus was recovered from the pus.

Growth Problems Following Osteomyelitis.—Speed [70] has been interested in the problems presented by a normal growth on one side and an impairment of growth, due to partial destruction of the epiphysis by an osteomyelitis, on the other. The epiphyses which unite last must be most carefully guarded. These are those, in general, away from the direction in which the nutrient arteries run. Thus the epiphyses of the knee, shoulder and wrist unite later than those of the hip, ankle and elbow. Unless a bony deformity is increasing very rapidly and interferes seriously with function or threatens skin necrosis, brace rather than operative procedures are favored for a year. In adolescents, if both clinical and roentgen-ray examination during the course of the year demonstrate marked disturbance of growth, Speed favors equalizing the length of the legs by resecting a portion of the normal companion bone. If the child is young, with many inches of growth expected, after two or three years, when it is quite positively established that the epiphysis of the damaged bone has ceased all growth and is destroyed, the author advises the excision of the epiphysis on the other side (epiphysectomy) to stop the overgrowth, each bone growing at an equal rate from the remaining epiphysis.

[ED. NOTE.—We have had no experience with this method, epiphysectomy, for controlling growth and obviating marked differences in length in companion bones, one of which has been damaged in its growing center by an osteomyelitis. It seems to us to be a rather hazardous procedure. We should feel that any thorough destruction of a zone of growth might well interfere with the normal contour of the joint surface, if not at once, in subsequent years, and that an arthritis on the originally well side might be added to the child's locomotive difficulties.]

LOW BACK PAIN

Funiculitis.—Sicard and Forestier [71] maintain that persistent low back pain from which tuberculosis, syphilis, gonorrhea, typhoid and

69. Satta: Chir. d. org. di movimento **6**:97 (Feb.) 1922.
70. Speed, Kellogg: Surg., Gynec. & Obst. **34**:469 (April) 1922.
71. Sicard, J. A., and Forestier, J.: Presse méd. **30**:45 (Jan. 18) 1922.

other infections can be excluded, is often caused by a funiculitis rather than a radiculitis. The seat of the trouble they believe to be in the funiculi. Removal of the appropriate laminae has relieved symptoms in their five cases, by opening up the intervertebral foramina.

Anatomic Variation.—Léri [72] sounds a timely note of warning as to holding anomalies of the fifth lumbar vertebra responsible for low back pain. He points out the very frequent occurrence of these variations from the normal, in patients free from all symptoms and urges very careful elimination of other possible causes of pain before ascribing it to enlarged transverse processes and partial or complete sacralizations of the fifth lumbar vertebra. Finding a sacralization is not making a diagnosis.

O'Reilly [73] also calls attention to the common occurrence of these variations from the absolute norm. He thinks that marked variations represent inherent weakness and aggravate and prolong symptoms when spines presenting such abnormalities are subjected to strain.

Holland,[74] writing on the same subject, reports ten cases, three of which were in children under 11 years of age. In a child of 2½, the lateral masses of the sacrum are seen to be developing from two bone centers.

O'Ferrall,[75] after reviewing forty cases of low back pain from the Orthopedic Clinic of the Touro Infirmary, concludes that the symptoms are usually due to sprains or infectious arthritis of the lumbosacral joints. In his series, there were twenty-two cases of sudden onset, suggesting a true sprain, while eighteen had an insidious onset and in his opinion were due to infections. He has been impressed with the importance of searching for remote foci by making a very complete physical examination. He considers that venereal infection, especially syphilis, is a frequent etiologic factor.

Kuth [76] has analyzed 208 cases of low back pain occurring in 136 males and 72 females. Of 180 patients, eighty had had previous attacks. In seventy-five, trauma was a possible cause. Unfavorable static conditions in the spine or lower extremities, occupational strain, operate as a direct cause to produce and prolong symptoms. The best results in relieving these symptoms were obtained when these static abnormalities were corrected, together with graduated systematic exercises.

[Ed. Note.—It seems to the Editors that Kuth has laid stress on a most important feature of these cases of persistent low back pain.

72. Léri: Presse méd. **30**:158 (Feb. 22) 1922.
73. O'Reilly: Southern M. J. **15**:217 (March) 1922.
74. Holland, C. T.: J. Bone & Joint Surg. **4**:215 (April) 1922.
75. O'Ferrall, J. T.: J. Bone & Joint Surg. **4**:384 (April) 1922.
76. Kuth, J. R.: J. Bone & Joint Surg. **4**:357 (April) 1922.

We agree in a general way with O'Reilly that marked anatomic variations and fifth lumbar partial or complete sacralizations represent potential weakness. We know that adventitious bursae often exist with enlarged fifth lumbar transverse processes. However, these abnormalities have been present often during many years of active life and have not caused symptoms. Then, as a result of fatigue or strain, faulty statics and poor postures become habitual, and the anatomic variation becomes, in combination with the wrong bodily mechanics, a source of irritation and pain. Certain it is that relief may be obtained by the correction of these postural defects by means of temporary supports and persistent exercises looking to the establishment of a muscle tonus which shall maintain correct attitudes of rest and activity. Surgery should be the last and, we believe, the rare resort. Removal of a supposedly offending transverse process is a serious major operation, and, by restoring correct statics, we may expect, in the absence of articular disease, to escape the necessity of ankylosing operations on the lumbar spine or sacro-iliac joints, valuable as these procedures in the occasional case may be.]

SCOLIOSIS

Lionti [77] calls attention to a form of scoliosis due to the ptosis of one kidney. Dieulafé, Bagozzi and Bender have reported cases and Girolamo adds one of his own. The scoliosis is, in its early stages, purely functional and has disappeared in three of the cases after nephropexy; the fourth patient refused operation. The concavity of the curve may be on the same side as, or on the opposite side from, the ptosed kidney.

Operative Treatment of Scoliosis.—Sauerbruch [78] considers that the results he has obtained from operative procedures on the ribs in two cases of severe structural scoliosis warrant the hope that more complete correction can be obtained by operative than by nonoperative treatment alone. He has noted that in fibroid phthisis there is always a deflection of the spinal column toward the normal side. Following paravertebral resection of the ribs, the column bends slowly back, and, in certain cases, an overcorrection has occurred. With Lange he operated on a patient with high grade fixed scoliosis. Their plan was to resect a portion of all the ribs on the concave side. The operation was performed in two stages. At the first operation, the three lower ribs were attacked, because these deep-lying structures are the most difficult to reach beneath the muscles. No appreciable improvement occurred under gymnastics. Three months later, the first seven ribs

77. Lionti: Riforma med. **38**:199 (Feb. 27) 1922.
78. Sauerbruch: Arch. f. klin. Chir. **118**:550 (Nov. 24) 1921.

were resected, from 4 to 5 cm. being removed. No immediate improvement occurred; but, under gymnastic exercises, the body was gradually drawn over from the right convex to the left concave side and the patient became able to assume an erect position.

To offset the effect of the approximation of the ribs on the concave side, Frey, Sauerbruch's assistant, proposed the expedient of gathering together the widely separated ribs on the convex side. His experiments on animals seemed to demonstrate that such a procedure was effective (seen next review of Frey's article), especially when a portion of the ribs on the concave side had been resected previously. Sauerbruch employed this method in the case of an 18 year old girl, first resecting all the ribs on the concave side and then drawing the third, fourth, fifth, sixth, and seventh ribs closely together on the convex side by means of copper wire. He says that at the time the first dressing was removed the result was most surprising: the spine might have been called straight. Unfortunately, the wires cut through the ribs and were expelled.

Acting on a second proposal of Frey, Sauerbruch operated on a 17 year old boy in two stages. At the first operation, a 3 cm. section was resected from the second to the ninth ribs on the concave side. At the second operation, a similar section was removed from the second to the eighth ribs on the convex side. A plaster cast was then applied in extension, with slight pressure on the scoliotic convexity of the chest. Eight days after the removal of the cast, the scoliotic convexity of the chest had nearly disappeared, and the curvature of the spine was considerably less.

Frey [79] reports his experiments on dogs and guinea-pigs of tying together several ribs on one side. This induced a scoliosis, which was more pronounced if the ribs on the other side were severed. In cadavers also section of the ribs on one side and close approximation of the ribs on the other side produced a scoliosis, the degree of which depended on the elasticity of the subject's spine. From these experiments, Frey argued that, in cases of structural scoliosis, tying the ribs together on the convex side would tend to correct the deformity, and that resection of a portion of the ribs on the concave side would make correction more rapid and complete. He reports the partially successful accomplishment of this result in Sauerbruch's second case, to which reference has been made above. He admits that with much fixed rotation the spine must be first mobilized. He believes this may be accomplished by dividing the ribs on the concave side close to the spine and the corresponding ribs on the convex side at a distance from the spine, after which a correcting cast is applied with head extension.

79. Frey, E. K.: Deutsch. Ztschr. f. Chir. **169**:13 (Feb.) 1922.

The ribs regenerate very rapidly, and he reports that the correction thus obtained in two old and extreme cases in boys of 16 and 17 was soon apparently permanently stabilized.

[Ed. Note.—These major operative procedures of Sauerbruch and Frey are certainly daring and based on suggestive experimental work. They recall the similar and partially successful work of Hoke [80] with a single case, which work we believe he never cared again to undertake. It is true the experience of the war has widened the field of thoracic surgery, and it may be that these extensive rib sections and resections will be found safe in less skilful hands than those of this eminent German surgeon. There may also be devised safe methods of utilizing the procedures which Frey has discovered are capable of inducing a scoliosis, and by their reverse application these methods may succeed in correcting an existing scoliosis. More experimental work needs to be done, and the end-results of more cases must be reported by the originators of these methods before the importance of their contribution to the treatment of structural scoliosis can be estimated.]

Krukenberg [81] emphasizes the importance of the psoas muscles in the pathology of lateral curvature. He likens the spine to a ship's mast held by four ropes, two of them being represented by the erector spinae and two by the psoas muscles. He believes the function of the psoas muscles is not so much the flexion of the hips, as the support of the spine. In lumbar scoliosis, this function is disturbed, and the psoas on the concave side acts as a bowstring and its contraction tends to increase the deformity, while the psoas on the convex side becomes weakened and stretched. Krukenberg, therefore, divides the psoas tendon on the concave side through an incision in the groin, finding the approach easier here than at its insertion, where it is also intimately connected with the tendon of the iliacus, which he does not wish to divide. In several cases, he reports being able to lengthen the spine 10 cm., and he has obtained a marked improvement in the deformity. After the operation, the spine is stretched while the patient is under an anesthetic and a spica applied. The author has also succeeded in improving the curvature by changing the direction of pull of the external oblique muscle which he finds altered in shape and function in scoliosis. His technic is as follows: In a case of severe right lumbodorsal scoliosis, the aponeurosis of the left external oblique is divided through a pararectus incision, extending from the xiphoid cartilage to the inguinal ligament. A horizontal incision is next made, following Douglas' line. The upper portion of the muscle retracts, and the lower portion, which overlaps the rectus, is fastened to its sheath

80. Hoke: Am. J. Orthop. Surg., November, 1903.
81. Krukenberg: Ztschr. f. orthop. Chir. **42**:193, 1922.

in such a way that the right half of the abdominal wall is drawn toward the left side. He reports very encouraging results in three cases and suggests that the operation may, in certain instances, be combined with the tenotomy of the psoas, to which reference has been made above. Krukenberg has observed no unfavorable result from this operation in lessening the resistance of the abdominal wall.

Nonoperative Treatment of Scoliosis.—Klein [82] states that the aim of the Scoliosis Clinic of the Massachusetts General Hospital is "to improve the symmetry of the severe scoliotic, so that after the maximum amount of correction has been obtained the muscles may become, with proper training, adequate to compensate for the remaining deformity." The methods followed are: first, carefully supervised exercises to mobilize the contracted muscles and ligaments and to acquire complete control over the respiratory muscles, the importance of which had been previously demonstrated by Bucholz. When this control is obtained and this mobilization accomplished, the patient is placed in the Abbott frame and a fenestrated corrective jacket is applied, the pelvic girdle being rotated on a shoulder girdle as a fixed point in a direction similar to that employed by Forbes. Felt padding is applied once a week between the posterior convexity of the ribs and the cast, and the cast itself changed when it is no longer effective, the series being interrupted by exercise periods and split or hinged casts. Klein is insistent on the avoidance of any considerable muscular atrophy, and his cases show that he is successful in his attempt. As soon as the maximum amount of correction by cast has been obtained, the patient resumes muscle strengthening exercises and is fitted with a light retaining brace, the essential feature of which is an accurately fitting pelvic base. The general condition of the patient is checked up by medical examination and is of chief concern throughout the course of treatment, which before the case is accepted, the patients agree to continue for at least two years.

BODILY MECHANICS

Posture and Cervical Rib Syndrome.—Todd [83] reports an interesting personal experience tending to demonstrate that the cervical rib syndrome may be produced by posture alone. In 1913, he contracted the habit of sleeping with his right arm stretched out almost vertically and his hand under his head. His first symptoms were noticed in January, 1921, and consisted of tingling of the right index finger and thumb, and finally paronychia and desquamation. In March, 1921, the position of the arm in sleeping was changed, because the symptoms became

82. Klein, A.: Treatment of Structural Scoliosis at the Massachusetts General Hospital, J. A. M. A. **78**:418 (Feb. 11) 1922.

83. Todd, T. W.: Ann. Surg. **75**:105 (Jan.) 1922

so marked as to interfere with the use of the hand and fingers. In two months, the symptoms had largely disappeared, and the fingers had almost returned to normal.

Effect of Bodily Mechanics on the Health of Children.—Talbot [84] has become convinced of the association of faulty bodily mechanics and constipation, cyclic vomiting, recurrent attacks of so-called acidosis, fever and abdominal pain of unkown cause. Fatigue and bad posture go hand in hand and form a vicious circle which must be broken. He recommends that recumbency in the hyperextended position, lumbar spine flat, costal angle widened, and thorax lifted and stretched, be assumed by these patients for at least one-half hour after each meal, and if possible, for an hour after the noon meal. Postural exercise training he believes important also, and occasionally the application of a retentive brace under orthopedic supervision.

Orthopedic Examination of One Thousand Three Hundred and Ninety-Three Yale Freshmen.—Cook [85] has made a statistical study of postural conditions in an entering college class. He is impressed, as Lee and Brown have been at Harvard, with the low percentage of normally poised students. In measuring postural scoliosis by a plumb line from the seventh cervical, which should normally coincide with the line of the buttocks, he found that only 49.7 per cent. of the students showed no deviation. Only 3.5 per cent. showed no rounding of the shoulders, and only 44.1 per cent. stood with normal anterior posterior curves of the spine. In more than 50 per cent., the chest was to some extent flattened.

[ED. NOTE.—These figures certainly show, as do those of Lee and Brown and the examination of army recruits, that much needs to be done in the way of physical training of American youth from childhood through adolescence and early youth if we are to develop a race of greatest efficiency.]

Position and Activity of the Diaphragm as Affected by Posture.—Adams and Pillsbury [86] have studied the position and activity of the diaphragm in different postures. They find that the diaphragm is highest in the prone position, intermediate in standing, and lowest in sitting. In these three positions, the diaphragmatic excursion is equal on both sides. With the body lying prone on the right side, the right dome is higher than the left and the excursion on the right is twice as great as on the left; with it lying prone on the left, conditions are reversed. The extreme excursion is 6 cm., and the position of the

84. Talbot, F. B.: Southern M. J. **15**:171 (March) 1922.

85. Cook, R. J.: J. Bone & Joint Surg. **4**:247 (April) 1922.

86. Adams, R. D., and Pillsbury, H. C.: Arch. Int. Med. **29**:245 (Feb.) 1922.

heart accompanying changes in the position of the diaphragm is subject to wide range. In lateral recumbency, the dependent lung is relaxed and its diaphragmatic ventilation is in excess of that of the upper lung.

Orthostatic Albuminuria.—Willy Rieser and S. L. Rieser [87] have studied two cases of orthostatic albuminuria in women, aged 24 and 28, respectively. They were of the low blood pressure type, 106 and 118, systolic. Without corsets, the patients both developed an albuminuria; with corsets, no albuminuria existed. They conclude that there is no relation between lessened blood pressure in the upright position and albuminuria. They believe it to be due to a renal stasis caused by compression of the left renal vein in the arterial pincers made by the aorta and the mesenteric artery. These pincers become active when the kidney is thrust forward by a lordosis or the mesenteric artery is pulled to tautness by the tug of a ptotic mesocolon.

Circulatory Disturbances in the Feet.—Geist [88] calls attention to the frequency of circulatory disturbances as a cause of "foot complaints." In his series of sixty-seven cases, twenty-three were cases of varicose veins, and forty-two of arterial disease, falling into four groups: (1) congenitally small arteries, (2) arterial spasm, (3) arteriosclerosis and (4) thrombo-angiitis obliterans.

BONE AND JOINT SURGERY

Recurrent Dislocation of Patella.—Drehmann [89] considers that every case of recurrent dislocation of the patella must be dealt with individually and that no one surgical procedure is appropriate for all cases. Thus, bone, muscular, tendon and capsular operation, or combination of these, may be advisable. He reports an excellent result from utilization of the gracilis. He exposes the lower portion of the tendon by a longitudinal incision, dividing the tendon at its insertion near the tibial tubercle. A second incision is made a little above the patella, and the tendon pulled up underneath the skin, passed through a slit in the quadriceps expansion at the mesial edge of the patella, and finally inserted into the mesial condyle of the femur.

Tenodesis of the Quadriceps Tendon.—In cases of quadriceps paralysis in young subjects in which it was important not to disturb growth, Saxl [90] has been able sufficiently to stiffen the knee for weight bearing by a tenodesis of the quadriceps tendon. A longitudinal incision is

87. Rieser, Willy, and Rieser, S. L.: Etiology of Orthostatic Albuminuria, J. A. M. A. **78**:644 (March 4) 1922.

88. Geist, E. S.: Minnesota Med. **5**:98 (Feb.) 1922.

89. Drehmann: Zentralbl. f. Chir., 1921, p. 629.

90. Saxl: Ztschr. f. orthop. Chir. **42**:138, 1921.

made over the center of the tendon, splitting the fascia. Two lateral incisions, one on each side of the tendon are then made, and the tendon lifted and its posterior portion scraped and freshened. The tendon is then displaced laterally and the periosteum beneath incised longitudinally in the midline and pushed back on either side, carrying with it some of the muscle fibers of the subcrureus. The underlying surface of the femur is freshened with a chisel, and the scraped under surface of the tendon placed in contact with it. The pushed back periosteum is then sutured to the edges of the tendon, and the vastus internus and externus are sutured together over the tendon. A plaster cast in extension is applied for three months, followed by a light extension apparatus for a few months longer. The slight spring in the joint allows a more elastic gait, and sufficient rigidity is eventually obtained to allow weight bearing without apparatus. He reports six cases.

Lengthening of the Quadriceps Tendon.—Bennett,[91] in a previous paper, has called attention to the part which the quadriceps tendon plays in the loss of mobility of the knee joint, following fractures of the femur, etc. Bennett has performed his operation of lengthening the quadriceps tendon in twelve cases, in the last four of which motion of at least 90 per cent. has been gained. The author makes the following comments: (1) Contraction of the quadriceps without adhesions will produce loss of function of the knee. (2) Contraction and adhesion between the muscles themselves, or between muscle and bone, will produce loss of flexion of the knee. (3) The capsular changes which offer obstruction to flexion before the tendon has been released yield easily after lengthening the tendon. (4) Contraction of the muscular tissue following long immobilization for inflammatory knee joint disease occurs; but, in the presence of a sensitive joint, it is unwise to operate. (5) Time is an important factor. A patient who has walked five years with 10 degrees of motion is a better operative subject than one who has walked only five months, though his range of motion may be three times as great. In the former case, the joint and muscle tissue are in good tone and regain their function more quickly following operation.

Results of Tendon Transplantation in Irreparable Paralysis of the Radial Nerve.—Perthes[92] reports the end-results in forty-four cases of tendon transplantation at the wrist for musculospiral paralysis. His operation is performed as follows: Having separated the extensor tendons of the fingers from their muscles, including the extensor longus pollicis, he divides the powerful flexor carpi ulnaris at its insertion to the pisiform, and, leading it around the outer border of

91. Bennett, G. E.: J. Bone & Joint Surg. **4**:279 (April) 1922.
92. Perthes: Klin. Wchnschr. **1**:127 (Jan. 15) 1922.

the ulna, attaches all the finger extensors and the extensor longus pollicis to it. He then attaches the tendon of the flexor carpi radialis to the detached tendons of the abductor longus pollicis and extensor brevis pollicis at the outer border of the radial epiphysis. He expects the new function to be assumed in from three to nine weeks. He has succeeded in restoring almost complete power of opening the hand and extending the fingers. The hand can be lifted well above the horizontal plane. As a rule, the power of closing the fist powerfully is lessened. If heavy labor is necessary, in order to make possible a more powerful closure of the fist, he attaches the tendon of the short radial extensor to the lower end of the radius, while the wrist is held in slight dorsiflexion. He considers the transplantations, however, much more important than this tenodesis.

Transplantation for Paralysis of the Opponens Pollicis.—Two methods of tendon transplantation in cases of paralysis of the opponens pollicis are said to have yielded excellent results: (1) By the method of Krukenberg[93] the radial portion of one of the flexor tendons of the middle finger is split off at the wrist, the transverse carpal ligament being nicked to make it possible to obtain a little more length of tendon. This slip is then drawn distally and pulled through a tunnel made to the base of the thumb, to which it is attached subperiosteally. The thumb is placed in the palm, and the middle finger extended, to remain for thirty days. The result of the operation is that the thumb can be opposed to the rest of the hand without closure of the fist. (2) The second method is that of Nicolaysen,[94] who for paralysis of the opponens and flexor brevis pollicis, transplants the abductor minimi digiti to the metacarpal bone of the thumb, which operation the author finds was first proposed by Huber. He reports an excellent functional result. In these cases there is frequently a subluxated or very relaxed joint between the first metacarpal and the trapezium, for which relaxation Spitzy has performed an arthrodesis. Nicolaysen anticipated the possible necessity of this in his case, but found the functional result satisfactory without it.

Functional Prognosis of Tendon Injury of the Finger and Hand.—Lier,[95] from material studied in the Swiss Institution of Accident Insurance during 1919-1920, comprising 450 open and seven subcutaneous tendon injuries, considers the probable prognosis under various methods of treatment. He concludes that primary suture of open injuries of the extensor tendons is more successful than that of the flexors. Secondary suture is less successful in both groups. When

93. Krukenberg: Ztschr. f. orthop. Chir. **42**:178 1921
94. Nicolaysen: Deutsch. Ztschr. f. Chir. **168**:133 (Jan.) 1922.
95. Lier: Arch. f. Orthop. **19**:383, 1921.

the injury consists of a smooth, clean severance, the outlook is better. The prognosis is better when the injury occurs in the second and third decades of life. Wounds of the tendons in the neighborhood of the metacarpophalangeal joint were more favorable than injuries elsewhere. The chief cause of failure was the cicatrization of the tendon with the surrounding tissues. Return to work was a little quicker in extensor tendon injuries than in flexor injuries, from thirty-two to fifty-five days. With subcutaneous laceration of the extensor aponeurosis at the terminal phalanx, a common injury, the prognosis was not good and suture was found to yield better results than splinting.

[Ed. Note.—The latter statement of Lier's in regard to the superiority of the operative over the nonoperative method of treatment in ruptures of the extensor aponeurosis at the terminal phalanx is in accordance with the prevailing surgical teaching. The Editors can only state that after a considerable experience with both the suture and the hyperextended splint treatment, they have been impressed with the success of the latter. Union and excellent motion and function have been attained, even as late as five weeks after the rupture, by splinting the finger for two weeks in an aluminum finger splint extending from the palm to beyond the tip of the finger, the terminal phalanx being hyperextended. The palmar portion of the splint is removed at the end of two weeks, and only the finger splinted for from two to three weeks longer. Finally the terminal phalangeal joint is protected by a band of adhesive plaster, 3 cm. wide, for a few weeks more. It is often quite difficult to repair accurately a torn aponeurosis by suture, and the results of this method of splinting have been entirely satisfactory.]

Arthroplasty Versus Fixation of Elbow.—Bean's [96] article is a general discussion of the question as to whether from anatomic, mental, social and occupational standpoints an arthroplasty of the elbow, yielding some degree of stable motion or an ankylosis at an occupationally appropriate angle of flexion, is the better functional result. He has observed the results of a good many arthroplastic operations on the elbow and looked up the reported results of others, and considers the results not so favorable as is the general impression. He concludes that the operation, in the light of this uncertainty of result and the time necessary to bring it about, is to be advised in a very limited number of cases. He believes that the functional result, even with a few degrees of stable motion, following an arthroplastic operation, has no advantage over ankylosis or an excision with a partially flail joint.

[Ed. Note.—Our own observation of actual results leads us to agree in a very general way with Bean's conclusion. The elbow joint, however, because of its anatomic conformation and its freedom from

96. Bean, H. C.: Boston M. & S. J. **186**:313 (March 9) 1922.

weight bearing and great strain, is perhaps the most favorable joint in the body for arthroplastic operation, both as regards immediate result and its freedow from later painful arthritic changes. We believe the emphasis should be placed on the perfection of our technic in arthroplastic operations on this joint and on a careful selection of cases, avoiding perhaps patients performing heavy labor, rather than on the abandonment of the operation for the older methods of excision and ankylosis. The extremely favorable functional results which follow well conceived and executed arthroplastic operations on the elbow in carefully selected cases should lead us to continue our attempts to perfect our technic. We admit these favorable results are almost occasional at present, but we believe them to be most hopeful.]

Operative Mobilization of Stiff Fingers.—Hesse [97] discusses the appropriate time for arthroplastic operation on ankylosed finger joints. He urges great conservatism and long waiting. Never should these operations be attempted until at least six weeks have passed after any inflammatory signs. Perthes' rule is three months. He has abandoned tourniquets since he has had two cases of radial paralysis following the use of an Esmarch. He performs the operation through two lateral incisions between the anterior and posterior digital vessels. He resects as little as possible of the joint surfaces, but enough to allow full flexion and extension, and he carefully excises the cicatricial capsule. The results are by no means always satisfactory, the cause being usually the adherence of the overlying tendons to the bone and cicatricial changes in the overlying skin.

In this connection, an article by Cotton and Sawyer [98] is interesting. They report eight cases of stiff fingers as a result of various injuries and of varying duration up to one hundred and twenty-six days. The most favorable results which they have obtained from twenty-four hour traction and distraction in the line of deformity, followed by gradual change of pull toward flexion or extension as the case demands, lead them to believe that this method is superior to others.

[ED. NOTE.—We have commented in a previous Report of Progress on the ease with which this traction may be obtained by the employment of a forearm and palmar cockup plaster splint in which a circular or "banjo" shaped wire extending beyond the fingers has been incorporated. This wire loop can easily be bent to be in line with the deformity, and to it are attached the elastic traction strings extending from the adhesive or glued skin traction finger bands. This method was first devised by Danforth.]

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97. Hesse: Arch. f. klin. Chir. **119**:1 (Jan. 27) 1922.

98. Cotton, F. J., and Sawyer, E. J.: Boston M. & S. J. **186**:183 (Feb. 9) 1922.

Excision of Head of Femur in Hypertrophic Arthritis.—Platt,[99] after discussing the somewhat uncertain outcome of manipulation and arthrodesis of the hip joint in cases of painful degenerative or hypertrophic arthritis of the hip, reports gratifying results from a modified excision of the head of the bone. His operation consists in removing the overhanging mushroomlike portion of the head, leaving a considerable stump of the neck and a slightly expanded upper portion. His exposure is obtained by removing the great trochanter and attached muscles, and, after the stump of the head and neck have been carefully smoothed and covered with wax, he thrusts this into the acetabulum and reattaches the trochanter at a lower lever on the femoral shaft.

[ED. NOTE.—The Editors are in agreement with Platt as to the frequency of unfavorable results which follow manipulation and attempted arthrodesis of the hip joint in this type of arthritis. We incline to the belief that this operation of Platt's, or even a more complete excision, is rather more likely to relieve pain than manipulation or attempted arthrodesis. We say attempted arthrodesis, because, except in comparatively early cases when the range of motion rarely seems to justify arthrodesis, the nature of the pathologic process makes firm bony ankylosis, in our experience, hard to obtain. The articular ends, often devoid of cartilage, are eburnated for some depth, and, beneath this firm bone, the cancellous structure is very fragile, with frequent large open spaces or cavities, as Ely's bone sections show. These changes, which are almost always present in a well advanced case, are not favorable to bony ankylosis. In a recently observed case in a stout elderly woman, on whom an operation of arthrodesis was attempted, the weakened atrophic neck fractured at the slight trauma of removing the overhanging hypertrophic bone of the head. No recourse but a formal excision remained, and, though the end-result cannot be stated, the shock of the operation was slight and the convalescence has been much less uncomfortable than that following an arthrodesis, since only temporary fixation was necessary. At the end of six weeks, the patient has less pain and more motion than before the operation and can bear almost her whole weight on her leg without discomfort; there is, of course, the expected amount of shortening.]

Results of Arthroplasty.—Hohlbaum[100] reports from Payr's Clinic the results of arthroplastic operations on eighty-five knees, two hips and four ankles. The operations were performed between 1911 and 1921. In 78 per cent. of the knees, the results were "good"; in 22 per cent., poor with one death; in 55 per cent. of the hips, the results were good; in 45 per cent., poor with one death. The results of all the

99. Platt: Brit. M. J. **1**:672 (April 29) 1922.
100. Hohlbaum: Arch. f. klin. Chir. **117**:647 (Dec. 24) 1921.

ankle operations were considered satisfactory. The best results were obtained in stiffened joints following Neisser infections and in those ankylosed by injuries. Metastatic infections were less favorable, because of the great disturbance of muscle function. The end-result of an arthroplastic operation is often not reached for one or two years.

Kalima [101] has made macroscopic and microscopic studies of eighteen specimens from arthroplastic operations performed by Payr. The material included fourteen knee joints, three hips and one elbow. The connection between the bone ends was cartilaginous and bony. There was no evidence of inflammatory processes in the bone ends. While the ligamentous apparatus were least altered macroscopically, the capsular ligament and periarticular tissue were markedly altered. The capsular portions, microscopically, were seen to have undergone most extensive fibrous and cicatricial transformations. These studies would seem to indicate the necessity for radical removal of the capsular and ligamentous tissue in performing arthroplastic operations.

Results of Astragalectomy.—Armitage Whitman [102] has studied the end-results of sixty astragalectomies performed at the Hospital for the Ruptured and Crippled, about half by Dr. Royal Whitman and half by other surgeons. These operations were performed chiefly for paralytic calcaneus, but Armitage Whitman says that the usefulness of the operation has become so apparent that it is being employed for relief of paralytic valgus and varus, dangle foot and clubfoot. The results are best in the class of cases for which the operation was originally devised, talipes calcaneus. For varus and valgus deformities, it is a last resort, and the results are not so satisfactory. Especially likely to occur is a varus deformity if there is even a trace of power left in either the tibialis anticus or posticus. The common fault in operating is not to displace the foot far enough backward and anchor it there. Of the sixty cases examined, the results were considered satisfactory in fifty-one, or 85 per cent.; eight were improved and one was a failure. Ninety per cent. of the parents or the patients considered the operation a success.

Extra-Articular Bone Bridging for Arthrodesis.—Müller [103] has attempted in dogs to produce a stiffening of the ankle joint by extra-articular bridges of bone transplanted into the tibia and calcaneus. The attempts were failures, for in time the transplant formed a pseudarthrosis opposite the line of the articulation. The same pseudarthrosis formed when the attempt was made to bridge the articulation by stimulating the formation of an exuberant callus.

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101. Kalima: Beitr. z. klin. Chir. **124**:423, 1921.
102. Whitman, Armitage: J. Bone & Joint Surg. **4**:266 (April) 1922.
103. Müller, Walther: Beitr. z. klin. Chir. **124**:315, 1921.

Spontaneous Healing in Transplanted Bone.—Haas [104] transplanted freshly removed bones, which he fractured into muscle tissue and observed the healing of the fractures, though eventually the bone was absorbed. He concludes, therefore, that there is sufficient energy in the osteoblastic cells of a living bone transplant, even removed from all bony contact, to form a union between the fragments. He believes that these experiments clearly indicate the advisability of employing fresh living transplants for all purposes.

Slipping Rib.—Four articles on "slipping rib" have appeared in recent issues of the *British Medical Journal* by Davies-Colley,[105] Marshall,[106] Mahon [107] and Ewart.[108] Abnormal mobility of the lower intercostal joints they consider fairly common and capable of producing very annoying symptoms. In Davies-Colley's two cases, excruciating pain was produced by exertion, the sharp stabbing character giving place to a dull ache. A mistaken diagnosis of deep abdominal or thoracic lesion had resulted, in one of his cases, in the performance of a futile laparotomy. The removal of 3 inches (7.6 cm.) of the terminal cartilage of the tenth rib effected a complete cure in both of his cases. In one of Mahon's cases, the ninth rib was affected and successfully healed in the same manner. Marshall reports the removal of a small portion, three-fourths inch (19 mm.) of the cartilage, of the third rib in one case, and of the end of the eleventh rib in another case, with relief of symptoms.

Posttraumatic Spondylitis.—Kümmell [109] has written a late article on the disease which bears his name. He maintains that it is quite distinct from the changes seen in a compression fracture which are evident in the roentgenogram immediately following the injury, while in the cases of posttraumatic spondylitis the early roentgenograms show no changes, and only those taken at a much later period show the collapse of the vertebral bodies and destruction of the intervertebral disks. He mentions three stages in the disease: (1) the stage of initial injury with an immediately following more or less severe shock, superseded in a short time by continued local pain in the region of the affected vertebrae; (2) a stage of relative well being and the resumption of activity; (3) after weeks, months or years, the formation of a knuckle and the recurrence of increasing pain. The treatment, in his opinion, consists of recumbency for several weeks. If the patient, as is usual, is seen in the third stage, he is given a brace which he wears for from four to

104. Haas, S. L.: J. Bone & Joint Surg. **4**:209 (April) 1922.
105. Davies-Colley: Brit. M. J. **1**:432 (March 18) 1922.
106. Marshall, Poynton and Soltau: Brit. M. J. **1**:516 (April 1) 1922.
107. Mahon, R. B.: Brit. M. J. **1**:602 (April 15) 1922.
108. Ewart: Brit. M. J. **1**:622 (April 15) 1922.
109. Kümmell: Arch. f. klin. Chir. **118**:876 (Nov. 24) 1921.

six months and then abandons it if ankylosis is firm. He is inclined to favor an ankylosing operation on the spine as diminishing the period of convalescence and producing a more sure freedom from symptoms, especially in laborers.

Flexion Contractures of the Knees.—Maragliano [110] reports two cases of persistent flexion contracture of the knees in which forcible straightening and long retention in plaster have been followed by a recurrence of the deformity. In these cases, he injected 60 per cent. alcohol into the branches of the sciatic nerve supplying the semimembranosus, semitendinosus and the long head of the biceps. The result was an apparently permanent relief of the contracture.

Isolated Disease of the Tarsal Scaphoid, Köhler's Disease.—Risser [111] has observed a case of this peculiar disease with a typical roentgenogram of a small dense scaphoid. Without any support, the acute symptoms disappeared in approximately three months, and in six months, it was impossible to distinguish any difference in the shape or structure of the two scaphoids in the roentgenograms.

Diagnosis and Treatment of Common Injuries of the Shoulder Joint.—Lovett [112] points out the importance of recognizing the difference between sprains of the ligaments, muscular strains, injuries to the biceps tendon, rupture of the supraspinatus tendon, bursitis and synovitis in injuries of the shoulder joint. He advocates the use of the aeroplane or platform abduction splint in all cases. He believes that gradual abduction of the arm by means of such a splint is more efficacious and less painful in cases of adhesions than massage and nagging passive movements. Occasionally, manipulation under an anesthetic saves time. He considers that the saber cut incision of Jones and Codman offers the best approach for the repair of a ruptured supraspinatus tendon, and in cases in which a chronic subacromial bursitis has not yielded to treatment, or in which there is a calcareous deposit in the walls of the bursa.

[ED. NOTE.—We have called attention to the fact that under conservative treatment many of the patients in whom calcareous deposit in or about the bursa are evident in the roentgenograms not only are relieved of their symptoms, but also of their calcareous deposits, as far as the roentgen-ray evidence goes, by conservative treatment. We do not believe that the finding of these deposits, even of considerable degree, always indicates the necessity of operative removal. A very important factor in the production and relief of shoulder joint symptoms

110. Maragliano: Chir. d. org. di movimento **5**:659 (Dec.) 1921.

111. Risser, A. S.: Isolated Disease of the Scaphoid Bone of the Foot, J. A. M. A. **78**:647 (March 4) 1922.

112. Lovett, R. W.: Surg., Gynec. & Obst. **34**:437 (April) 1922.

of the bursal type or the type spoken of by Lovett as irritable arm or false neuritis, occupational neurosis, etc., is, in our opinion, the habitual position in which the shoulder is held and used. It will be found, we believe, that most of these patients carry their shoulder far forward, and relief is often prompt and permanent if, by a light webbing elastic brace fastened to the corset or trousers, the shoulder is held well back in use, and the position is made habitual by appropriate exercises and correction of the general posture.

FRACTURES

Fractures of the Forearm.—Magnuson [113] points out the fact that in fractures of the Colles and chauffeur type an injury to the distal radio-ulnar joint is a usual concomitant. Lack of recognition of this injury often leads to a limitation in supination. Fractures of one or both bones above the wrist should be fixed in the neutral position, or in full supination, since the space between the two bones is widest in these positions. In fractures proximal to the insertion of the pronator radii teres, Magnuson advocates open reduction because of the diverse muscle pulls, the likelihood of excessive hemorrhage due to injury of the nutrient artery and because of the greater danger of synostosis at this level. Fractures of the ulna proximal to the middle result from direct violence and are frequently associated with dislocation of the head of the radius, which should be examined. The author advocates bed treatment with traction in suspension as the best method, believing that many of the bad results may be attributed to the ambulatory method and lack of traction.

Fracture-Dislocation of the Spine.—Hibbs [114] reviews twenty-two cases of fracture-dislocation of the spine, one in the cervical region, two in the dorsal, two in the dorsolumbar junction, and seventeen in the lumbar region. Eleven, or exactly 50 per cent. of the whole series, were of the fifth lumbar vertebra. There had been a comparatively recent severe injury in all but five of the lumbar cases. These patients had received injuries often not thought severe in childhood, with symptoms not appearing until adult life. At operations performed on three of these five patients, ununited fractures of the pedicles or laminae were found. Hibbs believes that these late symptoms may be accounted for by the failure of the adult completely ossified vertebrae to accommodate for the bony abnormality. He advocates bony fusion as a means of relief of symptoms and reports success in every case of his series in which it has been performed.

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113. Magnuson, P. B.: Mechanics and Treatment of Fractures of the Forearm, J. A. M. A. **78**:789 (March 18) 1922.

114. Hibbs, R. A.: Fracture-Dislocation of the Spine Treated by Fusion, Arch. Surg. **4**:598 (May) 1922.

Kidney and Bladder Function Following Gunshot Fractures of the Spine.—Cumming [115] makes a further report of observations on the cases reported by Plaggemeyer on a series of twenty cases of shell fracture of the spine. Nine more cases are added. They have refrained from continued catheterization and employed urinary antiseptics, daily enemas and mild laxative. His conclusions are as follows: (1) Since the observations made by Plaggemeyer and in most of the shell fracture cases, since injury, there has been no return of the reflex nervous control of the bladder. From the neurologic standpoint, in general, there has been decided motor improvement and less, if any, sensory improvement. (2) In several cases, partial sex function is recorded. In one case, the man married and reports normal sexual power since the spring of 1920. His bladder picture returned to normal, and the only disability remaining is a slight sensory loss in the genitalia. (3) All except a few patients with shell fracture have recovered good general health, even though they may not have excellent kidney function. In the fatal cases, the patients died early in the course of the disease, in every instance from kidney infection and uremia. (4) In all except the one case noted above, we believe that the bladders have retained the changes developing subsequent to the injury. Each patient carries a small amount of residual urine. (5) In no case has there been infection late in the progress. Other complications have been avoided, owing to avoidance of catheterization as far as possible. (6) Of the two surviving patients who had had kidney infection, both came to operation, one for early drainage with complete recovery, and the other after more than a year for nephrectomy. (7) Use of the sinusoidal current for bladder stimulation was apparently efficacious for a time, but in two cases serious complications developed. (8) Of supreme importance to the patients themselves is the fact that their general condition has improved to a point at which they are ambulatory, enjoying life to a degree seemingly impossible. Their bladders have taken on the automatic state with which they can be entirely comfortable. (9) Hyperhidrosis, a constant finding in these cases, has persisted to a varying degree. All the trophic ulcers have healed. (10) Repeated cystoscopy in one case had no detrimental effect. Following nephrectomy for pyonephrosis of long standing, the patient improved and increase in kidney function occurred. (11) The average amount of residual urine found in the cases included in this report was 260 c.c. (8¾ ounces). Two patients had a constant residual amount of 80 c.c. (27 fluidounces), making the average relatively high.

115. Cumming, R. E.: Shell Fracture of the Spine and Changes in Kidney and Bladder Function, J. A. M. A. **78**:335 (Feb. 4) 1922.

Fracture of the Pelvis.—Bacon [116] makes a report on thirty-two cases of fracture of the pelvis. The etiology is always direct violence, usually laterally applied, rather than anteroposteriorly. In this series, the pubic bone was fractured nineteen times, the ilium eighteen, and the ischium nine. Fractures of the ascending ramus of the ischium are the ones most commonly overlooked. Shock is nearly always present in pelvic fractures, and a slowly increasing ecchymosis in the pubic and perineal region is almost constant. Gross deformity is rare. The complications consist in tearing of the anterior and posterior ligaments of the sacro-iliac joints, which occurred in 25 per cent. of the cases and was the most disabling feature; 25 per cent. of the patients also sustained ruptures of the urethra and bladder, and half of these were fatal. Only one other case of the series resulted fatally. Nineteen of the thirty-two patients returned to their former work with an average disability of less than six months. In the treatment, he advises recumbency in a fracture bed, massage in three weeks, active and educative muscle movements in five or six weeks. He has discontinued the use of adhesive plaster strapping and plaster-of-Paris. The treatment of the shock is the most important. He believes that anatomic replacement in fractures of the ramus of the ischium, of the ramus and body of the pubic bone, or of the ilium near the acetabulum, is impossible by closed methods, and he advises against open operations.

Fractures of the Neck of the Femur.—Dorrance and Murphy [117] have employed the abduction method in twenty cases of fracture of the neck of the femur, all but two occurring between the ages of 60 and 80 years. Of these twenty, they consider nine to have a good functional result; three walked with a slight limp, four walked with a cane. The two cases occurring in younger subjects, ages 37 and 50, obtained bony union. The roentgenogram in seventeen of the cases revealed dense fibrous union, though clinically firm osseous union seemed to exist. A point in reduction which they consider important is that before abduction is carried out, the assistant makes strong traction downward while the operator makes strong traction outward on the upper third of the femur, manipulating the fragments into position.

Henderson [118] also is convinced that bony union in fractures of the neck of the femur is difficult to obtain. He is of the opinion that the operations of Brackett and Whitman open a wide field for surgery, and, if there is sufficient remaining neck and the patient is not too old, he believes that bone grafting and pegging have a place in the treatment.

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116. Bacon, J. E.: Southwestern Med. **6**:4 (Jan.) 1922.
117. Dorrance, G. M., and Murphy, E. C.: Penn. M. J. **25**:449 (April) 1922.
118. Henderson, M. S.: Penn. M. J. **25**:452 (April) 1922

Metatarsophalangeal Fractures.—In Bolduc's [119] series of twenty-seven cases of these fractures, the commonest injury was a chip fracture of the terminal phalanx of the toes. He thinks that the treatment of the fracture is always surgical, to relieve tension of the extravasated blood in the sac about the encapsulated end of the phalanx. The roentgen ray will reveal fractures in many cases of supposedly simple contusions.

Nonunion of Fractures.—An excellent article on the nonunion of fractures has been written by Waring and Milligan,[120] which does not lend itself to abstract. The authors have not found it necessary to employ elaborate methods of bone grafting, plating or wiring. They do not hesitate to shorten the bones if firm union may be thus more certainly assured, feeling sure that functionally this is of first importance.

Putzu [121] divides the cases of nonunion of the bones of the upper extremity into three classes: (1) nonunion of short duration, with fragments in good position and no suggestion of interposition of soft tissues. The treatment consists of various methods of physiotherapy and stimulation. (2) Nonunion in which the fragments are in good position with little or no loss of substance, but separated by foreign bodies or soft tissue. The treatment consists of osteosynthesis by one method or another. (3) Nonunion in which there has been a considerable loss of substance or the bone ends have lost the osteogenic power of regeneration. Treatment is accomplished by means of bone transplants.

DISLOCATIONS

Carpal Dislocation.—Speed [122] states that the cause of fracture dislocation of the carpal bones is always a fall on the hand. In fractures, immediate and prolonged immobilization is the only treatment likely to bring about union. If cases are neglected, nonunion and cavity formation result, and the excision of the whole bone is the procedure of choice. A dislocated carpal bone replaced very soon after the injury may renew its vascular connection and live. The compartment from which the bone escapes soon grows smaller and becomes filled with fibrous tissue, so that it becomes impossible to replace the bone or at least undesirable to do so, owing to the necessary damage to neighboring bones, while the dislocated bone, even if replaced, will probably lie in the wrist as an irritating foreign body.

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119. Bolduc, A. G.: J. Industrial Hygiene **3**:371 (April) 1922.
120. Waring, H. J., and Milligan, E. T. C.: Brit. J. Surg. **9**:408 (Jan.) 1922.
121. Putzu: Policlinico **28**:528 (Dec. 15) 1921.
122. Speed, Kellogg: Carpal Bone Fracture Dislocation, abstr. J. A. M. A. **78**:303 (Jan. 28) 1922.

Cohen,[123] on the other hand, in reporting a case of anterior dislocation of the semilunar bone, and reviewing the literature, concludes that closed reduction is the method of choice and may succeed as late as three weeks after the injury. In over 50 per cent. of the cases, dislocation of the semilunar bone is associated with lesions of the neighboring bones.

Cohen [124] also reports a case of dislocation of the pisiform bone associated with a partial slip of the distal radial epiphysis. A blow or muscular action may produce the lesion, which is very rare in spite of its exposed position. That it is so rarely dislocated is due to the fact that it has a certain amount of normal give or play and that its capsule is so strongly reinforced by extension from the internal annular ligaments and the insertion of the flexor carpi ulnaris. Cohen states that the disability resulting from the dislocation is slight and hardly warrants the procedure of suturing it back in place.

Dislocation of the Hip.—Bosch [125] has studied four personally observed cases of central luxation of the hip joint, reviewing the literature of seventy-five others. The mechanism of the fracture is a violent force acting in the direction of the axis of the neck. If at the time of the application of the force, the thigh is held in abduction, outward rotation and flexion, the head is driven into the anterior superior compartment of the acetabulum. If the thigh is held in abduction, inward rotation and flexion, the fracture occurs in the anterior inferior quadrant. Force great enough to fracture the acetabulum usually fractures other portions of the pelvis. Examination through the rectum is often helpful in diagnosis. The best method of reducing the subluxation is by continuous upward traction, combined with lateral traction. Bosch considers this much safer than forceful attempts at quick reduction, even if it requires heavy weights and twenty-four hours. When the trochanteric position had returned to normal, he succeeded in one case in reconstructing the acetabulum by pressure through the rectum. He advocates early voluntary motion, but freedom from weight bearing for ten weeks at least. If the lesion is unrecognized, much disability may be expected.

Campbell [126] reports a case of traumatic dislocation of the hip into the perineum, with avulsion of the greater trochanter. Every effort at close reduction failing, an open reduction was accomplished, twelve days after the injury. A thick aponeurotic band and the insertion of the gluteals was wrapped around the neck and resisted reduction. In four months, the result was extremely satisfactory.

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123. Cohen: Med. Rec. **101**:656 (April 22) 1922.
124. Cohen: Ann. Surg. **75**:238 (Feb.) 1922.
125. Bosch: Schweiz. med. Wchnschr. **51**:1129 (Dec. 8) 1921.
126. Campbell, W. C.: Perineal Dislocation of the Hip, J. A. M. A. **78**:1115 (April 15) 1922.

Subastragaloid External Dislocation.—Jones [127] emphasizes the seriousness of subastragaloid external dislocation, as shown by a study of the literature, and reports a case of his own, complicated by fracture of the neck of the astragalus. The mechanism of the lesion is strong pronation with eversion. Tenotomy of the Achilles tendon may facilitate reduction, permitting lateral replacement of the dislocated os calcis. Traction on the os calcis should be accompanied by strong supination of the forefoot. In compound fracture dislocations, necrosis of the astragalus seems to be prone to occur and an early astragalectomy should, in Jones' opinion, be considered.

AMPUTATIONS AND PROSTHESES

The Carnes Arm.—Radike [128] states that in Germany there has been a widespread demand for the Carnes arm, following the publications and demonstrations of Dr. Max Cohn. He recognizes the fact that it is a complicated apparatus and requires much training and long practice to obtain the necessary skill in its use, but he considers that its mechanical principles and its practical usefulness make it and the Sauerbruch arm the best forms of prostheses.

Cineplastic Amputations.—Ten Horn [129] estimates that in Germany there were between 2,500 and 3,000 amputations after the cineplastic methods of Sauerbruch. He reports a study of 403 cases, half of them three or more years after the operation. Eighty-three and five-tenths per cent. expressed themselves as satisfied with the result and the prostheses; 74.1 per cent. used the prostheses continually; 8.8 per cent., irregularly; 8.7 per cent., only for cosmetic purposes, and 8.4 per cent., not at all. Ninety-five and five-tenths per cent. were engaged in some occupation. Of the upper arm amputations, occupational ability was fully restored in 59.8 per cent.; 24.7 per cent., almost fully; 10.3 per cent., about half, and 5.2 per cent., only slightly. With forearm amputations, the figures were about the same, though a little less favorable. Of the total number of upper limb amputations, approximately 80 per cent. were able to resume fully or almost fully their former occupations.

Blencke [130] esteems the Sauerbruch method of amputation and his prosthesis very highly, but regrets that the results have not come up to the expectations in many instances, owing to the lack of firmness and muscle power in the canals and loops. This he believes is due to imperfectly executed operations and to the want of persistence and energy, on the part of patients, in exercises.

127. Jones, Ellis: J. Bone & Joint Surg. **4**:325 (April) 1922.
128. Radike: Arch. f. orthop. **19**:551, 1921.
129. Ten Horn: München. med. Wchnschr. **69**:230 (Feb. 17) 1922.
130. Blencke: München. med. Wchnschr. **69**:202 (Feb. 10) 1922.

Methods of Obtaining Long Stump in Thigh Amputation.—Sauerbruch [131] devised and executed a daring and apparently successful operation designed to supply a longer thigh stump in cases of high amputation or disarticulation of the femur. This consists of fashioning long skin flaps from the thigh, excising for tumor or osteomyelitis the necessary portions of the femur, incising the lower leg down to the ankle joint and turning the lower leg completely back on the thigh, implanting the lower end of the tibia into the acetabulum or the femoral stump. The tuberosities of the tibia became the condyles of the femur; the abductors and adductors of the thigh were sutured to the periosteum of the tibia and the vessels were uninjured. The operation was performed on a child, and the result was a completely movable stump, capable of weight bearing and rich in soft parts.

Obstinate Equinus of Foot Stumps.—Kortzeborn [132] calls attention to the frequent obstinate equinus which results in foot stumps, following exarticulation of the Chopart and Lisfranc types and in certain atypical amputations. The cause of this he states is the shrinking of the posterior capsule of the tibio astragaloid joint, which must be subperiosteally separated and the bones manipulated before a lengthening of the Achilles tendon will avail to correct the equinus and restore the bones to their normal position.

Wilson,[133] as a result of experience gained during the war, in the treatment of patients with amputations of the lower limb, has shown that it is possible to get such patients out of bed without crutches and actively bearing weight on peg legs or simple forms of artificial limbs at a period of two or three weeks after amputations. Early weight bearing is a great advantage to the patient because (*a*) it promotes healing of the wound by improving the circulation, and in cases with terminal localized osteomyelitis favors the separation and spontaneous discharge of sequestrums; (*b*) it hastens stump shrinkage and prevents muscle atrophy and the development of joint contractures; (*c*) it favorably influences the patient's morale; (*d*) it greatly shortens the period until the permanent artificial limb can be fitted, and reduces the need of frequent alterations to the socket and thereby greatly reduces expense to the patient. Provisional apparatus to secure early weight bearing may be made to best advantage of simple materials, in the use of which the surgeon is already skilled. With understanding of the advantages of early weight bearing in the treatment of amputations of the lower limb and of the little difficulty involved in its application, the method should be universally applied.

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131. Sauerbruch: Deutsch. Ztschr. f. Chir. **169**:1 (Feb.) 1922.
132. Kortzeborn: Arch. f. klin. Chir. **117**:758 (Dec. 24) 1921 .
133. Wilson, P. D.: J. Bone & Joint Surg. **4**:224 (April) 1922.

BOOK REVIEW

ARTIFICIAL LIMBS AND AMPUTATION STUMPS: A PRACTICAL HANDBOOK. By E. Muirhead Little. Philadelphia: P. Blakiston's Son & Co., 1922.

It is with great pleasure that we welcome this book which fills successfully a long existent gap in surgical literature. With the exception of a translated edition of Broca and Ducroquet's book on "Artificial Limbs" and another small book by Huggins on "Amputation Stumps," both of which are much less comprehensive, no authoritative work on this subject has been published in the English language since the war.

Mr. Little, in his capacity of consultant to the Royal National Orthopaedic Hospital and to Queen Mary's Convalescent Auxiliary Hospital at Roehampton, has had a particularly rich experience in the prescription and fitting of artificial limbs since the beginning of the war. Through his hands have passed many thousands of cripples representing every variety of problem, and this book embodies in a clear and detailed way his large experience.

The major part of the book is devoted to a study of various types of artificial limbs, and, in addition, he presents a complete description with illustrations of the official prostheses used by the British Ministry of Pensions. The British government, with about 40,000 cases of major amputations, early began experiments to develop improved types of apparatus, and many of the models finally adopted are superior to those which had been developed by private initiative alone. In the United States, the number of war cripples was not sufficient to stimulate originality on the part of the manufacturers, the ordinary industrial field being so large and profitable. The result is that our limb builders, although the best in the world before the war, have lagged behind their British cousins.

Cooperation between surgeon and limb maker is necessary for progress. The war has shown that few medical men know anything about artificial limbs. Those who perform amputations must know the requirements of a good stump and the functional possibilities of amputation at different levels, and should be able to advise the patient as to the best type of apparatus for him to use and where to obtain it. It is to be hoped that this book will do much to remove the present medical weakness.

MISCELLANEOUS

Brachial Plexus Injuries.—Adson [134] has studied the gross pathology of brachial plexus injuries by subjecting cadavers to various types of trauma, from two to three hours after death. Dissections were then

134. Adson: Surg., Gynec. & Obst. **34**:351 (March) 1922.

made, and the lesion of the plexus observed. (1) When the pull on the arm is downward and outward, as in a sudden attempt to release the hand or lower arm by jerking it away, extreme force may be followed by complete elongated laceration distal to the nerve trunks in the three cords. (2) In other types of trauma, the lesions of the nerves are situated in the vicinity of the intervertebral canal, proximal to the brachial trunks. (3) The lesions may be very slight, consisting of lacerations of the fascia about the cervical ganglion and the cervical trunk, with or without avulsion of the ganglion. (4) Patients with milder injuries may be expected to recover partially or completely, without surgical treatment. Those with more severe injuries rarely recover, even with surgical treatment.

Radiotherapy in Syringomyelia.—Coyon, Lhermitte and Beaujard [135] report great improvement in the gliomatous form of syringomyelia from systematic roentgen-ray exposures to the upper spine. In one case, after fifteen months' treatment consisting of exposures, every eight days, to the cervicodorsal region, the disease was apparently completely arrested. In their other case, a young man who was on the point of becoming helpless had his wage earning capacity restored after about thirty exposures in two stages. Thirteen years later, this patient died of pulmonary tuberculosis, and necropsy revealed a retrogression of the gliomas and an obliteration of the cavities in that part of the spine which had been exposed, while the gliomatous tendency in the unexposed portion had continued to progress slowly. No injury to the meninges or the nervous elements could be found.

Progressive Muscular Atrophy.—Goldthwait [136] describes a suggestive case of a man of 33 who for eight months had been suffering from a progressive muscular weakness affecting the upper and lower limbs, for which there was no discoverable specific cause. There had been some weakness of the knees and ankles, always exaggerated by use, for the last four to five years. There was obvious atrophy of the muscles of the legs, and less noticeable atrophy of the arm muscles, but no paralysis. There was some weakness of the abdominal muscles. The reflexes were all diminished. The chest was flat; the abdominal wall thin and relaxed, and a ptotic attitude was constant. The treatment was planned along the lines of correction of the bad bodily mechanics, in the hope of restoring a more normal physiologic balance. He improved markedly and surprisingly rapidly. A report, six and one half years later, stated that he had remained in good condition and was able to do all the work that could be expected of an active business man.

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135. Coyon, Lhermitte and Beaujard: Bull. et mém. Soc. méd. d. hôp. de Paris **46**:387 (March 3) 1922.

136. Goldthwait: Boston M. & S. J. **186**:559 (April 27) 1922.

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TRANSACTIONS OF THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

FIFTH ANNUAL MEETING, WASHINGTON, D.C., APRIL 29, 1922

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THE PRESENT AND FUTURE IN THORACIC SURGERY

SAMUEL ROBINSON, M.D.
SANTA BARBARA, CALIF.

It behooves the president of a well-established medical society to address its members in person. Regrettably, I am compelled rather to write you a letter apologizing for my unavoidable absence and wishing you a successful meeting and a free exchange of ideas on the subject to which this association is devoted.

I have chosen as my subject the present and future of surgery of the thorax. Would that I might so contrast the thoracic surgery of today with that of years gone by that its present status would be regarded as a blessed boon to humanity. Would that I might demonstrate that, as a result of persistent and untiring experimentation and clinical study, innumerable human beings are saved today who previously would have died. It would be a tremendous exhilaration to compile a list of modern operations which today might be combating pathologic conditions of the thorax with a success which our predecessors could not have conceived.

But alas, would the surgeon of fifty years ago look now with any degree of envy at the accomplishments of today?

The farmer may well console his mortification over the deficit from the crops of a dry year by picturing the harvests to follow the promised rains of the year to come; so, likewise, may we disguise our inadequacies in the thoracic surgery of today by dwelling on the possibilities of the future.

But for the present, let us face the present—not in the reflected light of future possibilities, but rather in the light of the actual improvement over the past.

Before the beginning of this century, a reluctance prevailed to enter the thoracic cavity for purposes other than drainage of fluids. Animal experimentation has since developed apparatus which has rendered an exploratory operation on the animal thorax a safe procedure. The danger of pneumothorax in wide operations on the human thorax has likewise been dispelled. Now, therefore, there need be no reluctance to enter the pleural cavity—at least not because of the region as such. This would seem to mark a great transition—a millenium. And some day, well it may; but since the development of differential pressure apparatus, has surgery of the thorax developed in anything like the

* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

expected proportions? Many wide open operations were successfully performed during the war; but most of them were performed without differential pressure. Let us define the actual progress creditable to this discovery. The transthoracic approach to the esophagus, otherwise impossible, is now safeguarded by the use of apparatus. If the technical difficulties of such operation are overcome, the ultimate success may be credited to the discovery of differential pressure and to the development of a perfected technic during the present period.

Operations for mediastinal tumors, for tumors of the chest wall, for bronchiectasis, for lung tumors should be performed with the aid of differential pressure, even though they may be successfully executed without such accessories. We may justly assert that such operations are now more willingly undertaken because of the safeguard provided by apparatus; furthermore, that the mortality in such operations is probably reduced in that group in which apparatus has been used. Even this claim could not be statistically proved. Until such time as we are able successfully to perform an intrathoracic operation with differential pressure which could not be performed without it, or until we can definitely prove that the mortality from such operations as may be performed with or without apparatus is lower with than without, we cannot claim actual progress.

In considering the various surgical diseases of the thorax in turn, where is progress revealed and where is it lacking?

EMPYEMA

I have recently reviewed this subject to date. The publications are legion. A large proportion of patients with acute postpneumonic empyema will recover in a short time following the single open drainage employed for centuries. There is no definite evidence that any new drainage device, suction device, irrigation technic or any other invention has lowered the mortality or reduced the chronicity in these uncomplicated acute cases. This is perhaps an extraordinary statement; but, I, nevertheless, defy any one to corral statistics from all available sources, including his own, which will prove the contrary.

One definite fact has been learned, that wide open drainage cannot and must not be instituted in the early stages of an acute hemolytic streptococcus empyema. The danger of a superposed operative pneumothorax in these cases is established. When, however, the pneumonic pressure has subsided, there is ample evidence that open drainage is tolerated as well as in the ordinary acute pneumococcus empyema. So, likewise, is a closed technic entirely proper in the hemolytic cases from the beginning to the end, if you please. But after weighing the advantages and disadvantages of the open and closed method of handling acute empyema, one cannot be accused of senility or bad surgery who reverts to the old pre-war technic.

Nevertheless, it would be ridiculous not to concede that the development of the closed method of treating acute empyema expresses a definite contribution.

The use of surgical solution of chlorinated soda (Carrel-Dakin solution), or other antiseptic, appears to me to be of great significance in the handling of cases of chronic empyema. Even though a closed method treatment of chronic empyema may frequently be inadequate to cure without a subsequent plastic operation, such an operation when performed is bound to be less extreme and less mutilating, and, consequently, less often fatal. The obliterative thickening of chronic empyema cavity walls under the cleansing and stimulating effect of Carrel-Dakin solution is unquestionably hastened. Cavities which would necessitate for their obliteration an elaborate, destructive operation of the Schede type may first be reduced in their proportions by antiseptic installation and irrigation applied by the closed technic; until, finally, if complete closure is not promising, a far less extreme plastic operation is sufficient to complete the cure. The best treatment of chronic empyema today is an intelligent combination of the antiseptic and operative treatments. Not infrequently, the operative portion of treatment should be first, in order to render a cavity in all its ramifications readily accessible to the irrigating solutions. In such instances, ribs and thickened pleura are excised not for the purpose of permitting caving in of the cavity, but rather of unroofing the cavity for inspection. The skin and muscle are then sutured in and over; a direct and unobstructed channel being left for the introduction of a tube or tubes to the remotest parts of the space to be sterilized and obliterated by closed treatment.

Should this association as such express its attitude regarding open and closed methods, Carrel-Dakin usage or omission, may we not denounce the establishment of two definite schools, one for, and one against, the closed treatment? The hyperenthusiast who has deceived himself sufficiently to believe that acute and chronic empyema are diseases always curable without any further surgical procedure than the introduction of a catheter or trocar is a menace to the community. So, likewise, is the pessimist, blind to the teachings of the day, who refuses to see any advantages in the closed method. He will occasionally openly drain and lose certain patients that would have been saved by closed treatment. He will perform extensive osteoplastic resections that might have been modified by Carrel treatment prior, or subsequent, to his operation.

The scrupulous surgeon of today will train himself in the technic of both the closed conservative and the open radical methods of handling empyema. He will be equipped with suitable apparatus and instruments

for both. He will intelligently discriminate between the cases suitable for one method and those better adapted to the other.

BRONCHIECTASIS

It has always been my belief that the greatest triumph in thoracic surgery will be the surgical eradication of this deplorable disease. The enthusiast returns from the war who has often dragged a lung lobe into a spread thoracic wound, opened it, scraped it, washed it—yea, even removed it—and concluded, therefrom, that intrathoracic surgery is freed of its supposed dangers, and that the possibilities therein are comparable to those in the abdomen. Let him attempt the same performance in his home hospital in a case of lower lobe bronchiectasis. Then will he learn what real thoracic pathology means. The patient is placed on the operating table. The posture is uncomfortable. There may be cyanosis. It induces coughing. The anesthetist is greeted by an evacuation of a large amount of pungent, purulent sputum, incident to the posture on the table. The whole bronchial tree may be filled with this material as the anesthetist begins. If regional blocking and paravertebral procainization is carried out, the pleura is no sooner opened and traction on the diaphragm commenced than the need of general anesthesia is obvious. As the secretions well toward the trachea, the cyanosis increases. The lower lobe obstinately resists being delivered; the pleural adhesions are strong and widespread; the attachments to the diaphragm are ropelike and tenacious. Finger dissection is inadequate. Work with the knife and scissors is blind. Cleavages are sought in vain. The pericardium is dangerously involved in the adhesions. Meanwhile, the patient's condition may become distressing and perhaps alarming. If open pneumothorax is adding insult to injury, the lung cannot be used to plug the thoracic gap, because the lobe is not deliverable. If differential pressure is being employed, that too may be acting badly. The mucopurulent secretion may interfere with proper intratracheal air insufflation. It interferes with the respiration under positive pressure. There may be cyanosis, even with the head outside a negative pressure cabinet. And then the difficulties multiply. The complete liberating at one sitting may have to be abandoned. There is bleeding and infectious leakage from the lung, and bleeding from the diaphragm. Tight closure of the chest without drainage seems inadvisable under such conditions, and yet necessary to avoid the ills of postoperative pneumothorax. Suddenly, it is obviously time to return the patient to his bed. Not much has been accomplished.

I have related this story of a more or less typical operation for bronchiectasis to emphasize the difficulties which are facing us in lung surgery. And, after all, the greatest dangers occur after the operation. It is the pathologic condition then developing which is likely to be

the patient's undoing. The pulmonary circulation is disorganized by the postoperative pneumothorax, closed or open, as the case may be. The respiratory apparatus is demoralized. The lung of the bad side is congested, following its traumatization. It is compressed by accumulated blood and fluid. Its better portions are incompletely filled because of restricted expansion. The diaphragm is fixed because its motions are painful; the chest wall is immobile for the same reason, and because of its constricting dressing, and the intrathoracic pressure has been so altered that lung expansion is further minimized.

Then come the dangers of pleural infection later in convalescence. There is more operating to be done. That person, then, with bronchiectasis who is fortunate enough to have disease in but one or two lobes, who withstands the severe primary operation and overcomes the subsequent derangements in his physiology sufficiently to withstand a second operation, and who meanwhile resists the infection incident to both, is, to say the least, fortunate. Nevertheless, we have obtained cures. Four years ago, the mortality was about 50 per cent. It is less now. Progress has been made and it will continue to be made. Let us labor persistently with the disease. The bronchoscope like the roentgen ray will help in the selection of suitable cases. Local therapy through the bronchoscope will perhaps abort the early cases. It will symptomatically relieve the inoperable cases, and it may cure those persisting areas of bronchiectasis which excisions have not included, or could not include. Radium or therapeutic roentgen ray may prove of value in conjunction with operation. We must further determine whether ligation of arteries or veins to a bronchiectatic lobe is of actual and permanent value, either as a cure or as a preliminary to lobectomy. I have mechanically produced bronchiectasis in dogs by ligating the main bronchus. The artificial bronchiectasis is devoid of the complicating elements resulting from infection as we see them in man; hence the excision of an artificially produced bronchiectatic lobe is not attended by the difficulties confronted in the human being. There is, nevertheless, an interesting field for animal experimentation.

There are other problems to be worked out in human bronchiectasis. Should a lobectomy be performed in one, two or three stages? Is there any advantage in delivering the infected lobe to the chest wall as a preliminary stage, disconnecting it subsequently by knife or cautery as the normal function of circulation and respiration becomes reestablished?

Can bronchiectasis be cured alone by arterial or venous ligation?

LUNG ABSCESS

Acute abscess of the lung continues to be a surgical disease curable by surgical drainage. I know of no specific improvement in technic. Methods of localization have improved. Certain plastic methods of

obliterating abscess cavities after drainage have been instituted. Some work has been done on the problems associated with the prevention and closure of bronchial fistulas; but nothing stands out conspicuously as an indication of progress. There remains a prevailing disinclination to diagnose these cases promptly and to attack them openly; but such are not the topics of this discussion.

Chronic lung abscess continues to baffle the surgeon. Drainage is of comparatively little value. I classify these cases with bronchiectasis, not that their pathology is by any means identical, but because excision is the type of surgical therapy which alone can combat such pathology.

TUMORS OF THE LUNG, PLEURA AND MEDIASTINUM

We must concede that little, if any, progress has been made in the surgical treatment of intrathoracic neoplasms; nevertheless, one of the obstacles has been removed, namely, the danger of pneumothorax which is necessarily incident to wide intrathoracic exploration. The use of apparatus safeguards the transpleural approach to tumors; but pneumothorax is perhaps the least hindrance to success. Primary tumors of the pleura are diffuse. They may be extensive and yet they may not invade the lung. The excision of such tumors is obviously impossible unless they are recognized at their incipiency, and such is clinically impossible. Primary tumor of the lung, on the contrary, is a surgical possibility. Occasionally, an isolated growth within a single lobe of the lung is recognized by the roentgen ray. Its situation, unfortunately, is more likely to be central or near the hilum than peripheral. The mediastinal glands are involved early. Nevertheless, a lobectomy or even an excision of that particular portion of the lung involved is technically possible. Be that as it may, our results in lung excisions are thus far attended with such high mortality that one cannot conscientiously advocate a surgical therapy when the success in roentgenotherapy and radiotherapy are ever increasing. Although a lobectomy for neoplasm ought to be technically simpler than that for bronchiectasis, the roentgen ray and radium serve as an alternative treatment for the former but not for the latter.

The surgical removal of mediastinal tumors has not met any degree of success, nor can it be pretended that any particular progress has occurred in this field. A case is occasionally reported, but the successful outcome has not resulted from any new development of technic, apparatus or instrumentation, but rather from the favorable situation of the tumor, from the lack of pleural involvement, and from the absence of metastasis. As to the future, I look rather to advance in roentgenotherapy than in surgical treatment. If the size of a mediastinal growth can be even so reduced by the roentgen ray that the usual distressing

symptoms are relieved, we are forced to substitute such treatment for a surgical attempt, the best attainment of which is likely only to be a partial removal of the growth.

TUMORS OF THE CHEST WALL

In this group, we can claim not only recent progress but also great promise for the future. These tumors are generally of osseous or periosteal origin from the ribs. They are circumscribed; they generally encroach on the pleura without involving it. The skin is rarely involved, consequently the thoracic wall defect, however extensive, may yet be covered by skin and subcutaneous tissue. To remove such tumors without opening the pleura necessitates a tedious dissection, associated ultimately with a pleural tear. This is one of the types of thoracic operation in which the virgin pleura is opened. There are no adhesions to prevent prompt collapse of the lung. If differential pressure is not employed, the operation is frequently interrupted by the onset of symptoms of wideopen pneumothorax. The pleural defect must be closed occasionally to restore normal breathing, this being done either by a gauze pad or by drawing the lung outside the body. Differential pressure in such cases averts these interruptions and obviates the dangers of wideopen pneumothorax, which, though rarely serious, are ever present in the operations outlined.

There is no evidence that the mortality in operations for excision of tumors of the chest wall has been lessened by the use of differential pressure. There is no evidence that these operations have been undertaken any more frequently because of this available safeguard. Frankly, then, if progress may be said to exist in this field, it cannot be credited to this developmental phase. Nevertheless, whatever may be the explanation, the surgery of the thoracic wall has experienced an advance. More and more patients will, from now on, be operated on, and, in the long run, it will be shown that the use of differential pressure in such cases is the indicated procedure.

TUBERCULOSIS

The surgery of pulmonary tuberculosis has advanced in the extrapleural field. Lung immobilization and collapse therapy are accomplished by various types of osteoplastic resections. Intrapleural procedures remain abandoned, essentially because the incipient processes which might be amenable to surgical excision are generally cured by hygiene; and in those cases in which advance has occurred, the process is too diffuse to be eradicated by surgical methods. The drainage of tuberculous cavities remains obsolete, and there appears to be no prospect of a renewal of such therapy.

Just why the progress in the chest wall caving-in operation is yet tardy, it is difficult to explain. The number of so-called cases and the many instances of great symptomatic relief would seem to be sufficient to warrant a more prevalent employment of such operations. And yet in a period of about twenty years, comparatively little has been done. Sauerbruch's Clinic at Zurich is watched with interest; but elsewhere the statistics are fragmentary. Many individuals might report, or have reported, from five to fifteen cases. If any well-trained American surgeon would devote himself exclusively to the study of the extrapleural surgical therapy of pulmonary tuberculosis, in conjunction with the director of a large tuberculosis sanatorium, I believe that, in a comparatively short time, his results would be so beneficial that a large surgical clinic would be established for this form of therapy.

TUMORS OF THE ESOPHAGUS

May the members of this association who have long labored in this subject continue to carry on. Would that their results were a greater reward for their undying persistence. If the intrapleural route can be perfected, the many dangers of the transpleural route are obviated. And here, again, we are confronted with the possibilities of radiotherapy and roentgenotherapy which may independently, or in conjunction with less radical surgery, produce results.

SUMMARY

To sum up the status quo of thoracic surgery, I argue that the progress of the last fifteen years has not been so creditable as we are sometimes inclined to suppose. The experimental field was laid open to us by the discovery of differential pressure, without which the dog's thorax cannot be widely opened for experimental surgery. Instead of making great use of this adjunct, we have neglected it in our zeal to employ differential pressure in operations on man, in whom its usage is rarely a necessity, though occasionally an asset. Experimental surgery has been conducted essentially in other regions of the body, although there are innumerable problems in thoracic surgery which must be solved by animal work. It behooves the workers of this association not only to carry on personally more experimentation, but to encourage our younger associates to engage in this type of laboratory experimentation. The annual programs of this association are lamentably lacking in reports from surgical laboratories, a fact which exposes the prevalent lassitude. Clinically, too, a far greater effort can be made. The surgery of the neck, the abdomen, the pelvis, the genito-urinary system and the extremities is far cleaner, more successful and more

remunerative. No surgeon today confines himself to the thorax, and, doubtless, this is in a sense fortunate; but our prevailing tendency is to give our thoracic cases the least attention. The internist is often heard lamenting that he cannot find a surgeon who will take any interest in his cases of thoracic disease.

Now that the interruptions of war are over, and our attention is again centered on the study of the diseases of civil life, I look for renewed progress in the chosen subject of this association.

SURGICAL TREATMENT OF THE ESOPHAGUS*

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NEW YORK

Eighteen years have passed since Sauerbruch solved the problem of attacking intrathoracic organs by means of his differential pressure chamber. By this invention, it was hoped that it might be possible to reach and remove carcinomatous tumors of the intrathoracic part of the esophagus which hitherto had been impossible of approach. In the beginning, the complicated apparatus stood in the way of popularizing the method, and only a few larger institutions were fortunate enough to be able to provide themselves with this costly differential pressure chamber. It has been my good fortune to be connected with an institution, the Lenox Hill Hospital (formerly German Hospital) in New York, which was the first in this country to erect a Sauerbruch chamber, as a result of the untiring efforts and enthusiasm of one of our members, Dr. Willy Meyer.

In the course of years, the method of using differential pressure has become materially simplified by the introduction of the Meltzer-Auer intralaryngeal and intrapharyngeal inflation and other positive pressure apparatus, such as those of Tiegel, Brauer and others. These simplified apparatus have brought the possibility of attacking the intrathoracic organs within the reach of every surgeon who is interested in the work.

After Sauerbruch's first publication, enthusiasm rose high, and an enormous amount of experimental work on animals was done, followed by trials of the methods on the human being. Unfortunately, the ultimate results of these operations on the human being did not keep pace with the results of experimental work on animals. This, of course, had a subduing influence on the enthusiasm of a good many workers in this difficult and complicated field, and at the Thirty-Ninth Congress of the German Surgical Society, Küttner said that, on account of the bad results which he had had, he had given up the operative treatment of carcinoma of the intrathoracic portion of the esophagus.

However, in our institution, a few men kept the light of enthusiasm burning in spite of disappointment after disappointment, until Torek, by his brilliant operation in 1913, which culminated in a lasting cure of carcinoma of the thoracic portion of the esophagus in a woman, proved beyond doubt the feasibility of transpleural esophagectomy. Up to the

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year 1914, intense and ingenious work had been done in this field. Then the unfortunate catastrophe of the World War came, and with it our subject almost entirely disappeared from the surgical literature in Germany, and for that matter in Europe.

Carcinoma of the esophagus is no longer a disease with 100 per cent. mortality, as it was heretofore. This fact stands out irrefutably, and beckons and pleads with us not to fold our hands and withhold from these unfortunate patients a possible chance of cure, however slim it may be in the individual case.

Many years before we knew how to avoid a fatal pneumothorax and before it dawned on us to attack the thoracic esophagus transpleurally, surgeons tried to reach the esophagus, in cases of injury or the presence of a foreign body, through the posterior, and even anterior, mediastinum, without opening the pleura. The first surgeon to work out a method of approach to the esophagus through the posterior mediastinum was a Russian by the name of Nasiloff.

The patient lies on the abdomen; the left arm is pulled upward. A hand's breadth from the vertebral column and parallel to it, an incision is made through the skin and musculature down to the ribs. At each end of this incision, a horizontal incision is made, which ends at the vertebral column. This quadrilateral flap is dissected up from the underlying ribs. If the operator wishes to reach the upper portion of the thoracic esophagus, this flap is made high on the left side, and pieces of the third to the sixth rib are resected. In case he wishes to reach the lower thoracic portion of the esophagus, the flap is made over the right and lower portion of the back, and pieces of the lower ribs are removed. After careful and double ligation of the intercostal arteries, the costal pleura is carefully pushed away from the ribs. He then enters the posterior mediastinum without opening the pleura. In this way, the aorta and the esophagus are reached with anatomic forceps or a grooved director; the esophagus is freed from the loose connective tissue which surrounds it, and it is then pulled out of the wound by a Langenbeck's resection hook.

This procedure has been employed by a number of surgeons [1] who, to suit their special cases, have more or less changed or improved it. Milton's method, described by Enderlen,[2] is interesting. He made a long incision from the thyroid cartilage to the ensiform process and divided the sternum in its long axis. By pulling the separated halves of the sternum apart, he gained a space from 5 to 6 cm. in width. Through

1. Quénu, Hartman, Potarca, Bryant, Rehn, Levy, von Hacker, L. Heidenhain and Bourienne.

2. Enderlen: Ein Beitrag zur Chirurgie des hinteren Mediastinums, Deutsch. Ztschr. f. Chir. **61.**

it, he asserts that he was able to reach the anterior and posterior mediastinum. Milton used this method in the removal of tuberculous glands from the anterior mediastinum. The patient recovered from the operation.

Enderlen,[2] who has carefully studied and critically reviewed these different methods, recommends the following operation as the best approach to the esophagus through the posterior mediastinum:

> A rectangular skin flap is formed, reaching from the third to the ninth thoracic vertebra, with its base toward the vertebral column, its outer edge close to the median border of the scapula. The soft parts are severed down to the ribs, and the flap is reflected. Subperiosteal resection of a piece of the eighth rib, 10 cm. in length, is performed. Subperiosteal resection of the eighth rib is the most difficult part of the operation. After this has been done, it is comparatively easy to lift the next higher rib away from the pleura and cut it. With some practice, one can thus reflect a flap containing the ribs from the eighth to the fourth, including the intercostal muscles, without opening the pleura. It is best to remove this whole flap, as its reposition is an unnecessary, complicating procedure. The pleura costalis is then carefully stripped off ventrally, and toward the spinal column. One has to be careful not to lift off the sympathetic trunk with the pleura, although Rehn believes this danger is remote. As soon as one has reached the anterior surface of the vertebral column, insertion of an esophageal bougie is recommended in order to facilitate recognition of the organ.

Enderlen states, and Sauerbruch is of the same opinion, that the next procedure, the dissection of the esophagus from its bed without injury to its walls, cannot be done. Its muscular coat is easily injured, and even both coats are easily torn. It is, however, possible by this method of approach to close a longitudinal wound in the esophagus by suture, as Rehm[3] has demonstrated. Enderlen believes it impossible to resect the esophagus in its entirety and to restore this lumen by a circular suture. Complete isolation of the esophagus and drawing it sufficiently out of the wound, he considers impossible. By this maneuver, the nutrient vessels would be injured to such an extent that a necrosis of their walls must ensue. That this opinion is not founded on actual clinical facts was later proved by Zaaijer[4] of Leiden.

In a case of a large diverticulum, the esophagus was completely isolated; two of its arteries were tied, and the esophagus was brought forward and sutured to the edges of the thorax wound. His operation proved that it is possible to isolate the esophagus to a great extent without grave disturbances of its circulation and subsequent danger of secondary necrosis. This demonstration of Zaaijer's has become of fundamental importance in the later developments of resection of this organ.

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3. Rehm: Operationen an dem Brustabschnitt der Speiseröhre, Arch. f. klin. Chir. **57**:733, 1898.

4. Zaaijer: Oesophagostomia Thorakalis, Beitr. z. klin. Chir. **77.**

Results with the posterior approach through the posterior mediastinum having been poor, this method was abandoned. Von Mikulicz [5] was the first to try to reach the esophagus from in front. This necessitated a broad approach through the thorax, which could only be accomplished under some form of artificial respiration. He tried the method in attempting a resection of the tumor in three patients with carcinoma of the esophagus.

Dobromissloff,[6] in Tomsk, later tried, in a similar fashion, to extirpate the esophagus. He operated on dogs. Under ether narcosis, a tracheotomy is performed, and artificial respiration established by means of an electromotor. A large flap, from 10 to 15 cm. long, is made of the thickness of the entire left thorax wall, from the sixth to the tenth rib, with the pedicle toward the back, within from 2 to 3 cm. of the spinous processes. The flap is reflected backward, and the intercostal vessels are tied. The pleura over the esophagus is incised, from the root of the lung down to the diaphragm. The vagus is severed. Blunt dissection of the esophagus is accomplished, usually accompanied by very little bleeding. A piece, about 3.5 to 4 cm. long, is excised, and the two ends are reunited by an end-to-end silk suture in two rows; from 1 to 1.5 cm. of the muscularis being taken up by the suture which does not penetrate the mucosa. This is followed by reposition of the thorax flap, suture of the intercostal spaces, musculature and skin. Air which had entered the thorax during operation is aspirated, after which artificial respiration is discontinued.

Dobromissloff reports a case in which a dog died three weeks after operation from overdistention of the stomach with food. At necropsy it was shown that the suture of the esophagus was well healed and intact, with a slight dilatation above. Experiments on the human cadaver convinced him of the feasibility of the operation, and he recommended its trial in suitable cases. It seems, however, that no other surgeon followed his suggestion, at least the report of no such operation has appeared in the literature. Sauerbruch has performed thirty experimental resections of the esophagus under artificial respiration with the same bad results, for which he mainly blames the artificial respiration.

PREVENTION OF PNEUMOTHORAX

The difficulties with which the surgeon is confronted are many and great. The greatest problem, the prevention of pneumothorax, has been overcome by the employment of differential pressure in some

5. Von Mikulicz: Ein Fall von Resektion des Carcinomatösen Oesophagus mit plastischem Ersatz des excidirten Stückes, Prag. med. Wchnschr. **11**:93, 1886.

6. Dobromissloff: Ein Fall von transpleuraler Oesophagotomie im Brustabschmitte d. Speiseröhre, Zentralbl. f. Chir. 1901, p. 1.

form, either negative or positive. The great controversy concerning the relative merits of plus or minus pressure has subsided, and it has been proved that there exists no difference in the two procedures. In fact, positive pressure, which for Sauerbruch and his followers has been anathema, has practically superseded negative pressure on account of the ease with which it can be employed. The greatest bugbear was to find a method of reconstructing the lumen of the esophagus by suture. Although it was demonstrated by experiments on dogs not only that a suture of the esophagus was feasible, but also that a perfect union without interference with deglutition could be obtained, it was also shown that in the human being suture of the esophagus invariably resulted in disaster. There are various anatomic reasons for this. The esophagus, which is only a thick, muscular tube, consisting of a muscular and a mucous coat, has no serosa like that of the intestine, which quickly agglutinates and forms adhesions. The mucous coat is rather tough and well adapted to suturing; the muscular coat, however, is very easily torn and the sutures cut through easily. Although it is possible to stretch the tube to such an extent that even a gap of from 7 to 10 cm. can be bridged over, the tension is so great that the sutures do not hold. Even if very much smaller pieces are resected and brought together and sutured, the tension from vomiting and retching becomes so great that the sutures tear through.

A good deal of ingenuity has been used to obviate this danger. Biondi, as early as 1896, published a method of resection of the intrathoracic portion of the esophagus which later became a most important cornerstone in the development of esophageal surgery. He opened the left pleura wide, incised the left side of the diaphragm, pulled a portion of the stomach into the pleural cavity, resected a piece of the esophagus, closed the lower stump, and made an anastomosis of the oral stump of the esophagus with the stomach. Mikulicz in February, 1904, resected 4 cm. of the lower part of the esophagus in a dog and made an end-to-end anastomosis. By mobilizing the esophagus in the hiatus of the diaphragm, he transposed the lower end, with the suture line, into the abdomen and stitched the diaphragm to the esophageal wall above the anastomosis. This experiment was successful. The dog lived for six weeks and died of a subsequent enteritis. Necropsy revealed: no pneumothorax, no empyema, slight adhesions of the lower lobe of the left lung to the diaphragm, slight stenosis at the site of suture and adhesions of the suture line to the stomach and duodenum.

Anschütz demonstrated that a part of the stomach can be transferred into the thoracic cavity by pulling it through the hiatus of the diaphragm, without interfering with respiration or the function of the diaphragm or of the stomach itself. Sauerbruch, therefore, tried to

bridge the gap in the esophagus by pulling the stomach upward. But all of his experiments, performed to obtain a good result either by suture of the esophageal stumps, or by closure of the lower end of the esophagus by inversion into the stomach and implantation of the upper end of the esophagus into the stomach, were more or less failures. He finally gave up the suture entirely and made the anastomosis between the stomach and esophagus by means of a button. He states that after mastering the technic he very rarely lost a dog after such an operation. Avoiding tension by transposing the stomach into the thoracic cavity, and discarding the suture, he believes, was a distinct advance. After the operation, a thorough cleansing of the thoracic cavity with physiologic sodium chlorid solution and the use of Lugol's solution to create early adhesions of the parts were recommended by him.

Whether this method of transposition of the stomach into the pleural cavity is really of no significance to the animal is questionable, and Levy is justified in doubting the advocacy of the procedure. Sauerbruch himself reports the sudden death of two animals, several days after the operation, from a diaphragmatic hernia of the stomach, the latter organ completely filling the left pleural cavity. Omi and Karasawa,[7] in their experiments on transposition of the stomach, lost two dogs immediately after incision of the diaphragm. Another animal died of a pulmonary disease; two others developed diaphragmatic hernias, in consequence of which one died five days after operation. The whole stomach, spleen and large omentum were lying in the pleural cavity. The other animal was fairly well and vomited only after overfeeding. It was killed one hundred and thirty-five days after operation. Necropsy revealed a rent, 3 cm. long, in the left part of the diaphragm. In the left pleural cavity were found the whole stomach, with the spleen, a loop of small intestine, the transverse colon and the greater omentum.

Freund [8] had about the same experience. Of six dogs operated on, only two lived. One died four months after operation of distemper; the other died six months after operation of an acute pancreatitis. In the first animal, the whole stomach was found in the pleura, and, in the second dog, a large part of the greater omentum and the spleen.

After the publications of von Mikulicz, Sauerbruch and Anschutz, on their experimental work, a great many other surgeons tried to solve the problem of suture of the esophagus. I shall mention only Green, Janeway and Willy Meyer, in this country, who have all tried, by

7. Omi and Karasawa: Beitrag zur Chirurgie der Speiseröhre, Deutsch. Ztschr. f. Chir. **124**:574, 1913.

8. Freund: Experimenteller Beitrag zur Querresektion des Oesophagus, Beitr. z. klin. Chir. **88**:423, 1914.

ingenious modifications, to work out a secure anastomosis between esophagus and stomach or between the two stumps of the esophagus. All their endeavors were failures. The use of a button for intestinal anastomosis, or its modifications, by Tiegel gave no more encouraging results.

After all these failures to establish a firm suture, Levy [9] came to the conclusion that in order to gain any headway in the operation for carcinoma of the esophagus, the whole esophagus, from the cardia to its cervical portion, should be removed. As far back as 1898, Levy had done a large amount of experimental work on operations for the removal of carcinoma of the esophagus. For many years, curious to say, his work was little known to the profession, at least, it seems to have attracted little attention. He operated on dogs, in which he first established a gastrostomy. Thereupon, he opened the esophagus at the neck and inserted a stomach tube, armed with a silk thread, 1.5 meters long. This tube was pushed down into the stomach until it could be pulled out through the gastrostomy opening. The thread was secured, and the stomach tube withdrawn. The thread was now lying inside the esophagus. The esophagus was then severed in the cervical region, and the upper aboral end of the esophagus was closed with the thread. By carefully pulling on the lower end of the thread which projected from the gastrostomy opening, he was able to invert the whole esophagus, pull it out through the stomach, and resect it outside. Levy tried this procedure on human cadavers, but came to the conclusion that it was not feasible in man. He says, "If you try to pull down the esophagus through a stomach fistula, you remove a tube which, in the cervical portion and a little further down, contains all layers of the esophagus. The largest part of the tube, however, consists only of mucous membrane and a more or less complete layer of ring-musculature, whereas the longitudinal muscle fibers are left behind."

Kelling,[10] in 1902, worked out a combined method of intrathoracic and abdominal resection of the lower part of the esophagus in which the whole esophagus was removed from the thorax and pulled out through a wound in the neck. He mobilizes the tumor by opening the thorax under artificial respiration. After this has been accomplished, the thorax is closed. The abdominal cavity is then opened; the esophagus mobilized at the hiatus of the diaphragm and cut through. A wooden cylindric plug is then inserted into its lumen, and a rubber finger-cot pulled over it to prevent leakage from the esophagus, with the subsequent danger of mediastinal infection. The esophagus is then

9. Levy: Versuche über die Resektion der Speiseröhre, Arch. f. klin. Chir. **56**:839, 1898.

10. Kelling: Zentralbl. f. Chir., 1902.

invaginated by means of a string and pulled up into the neck. Here an incision is made and the esophagus pulled out through the neck wound. Nutrition is kept up by gastrostomy feeding. This method of removing the entire esophagus from the thorax has become an important principle in the development of the operation of resection for carcinoma. Kelling himself has not followed this idea because he deemed the procedure too dangerous and too complicated to be tried on the human being. Küttner and Schneider also advocated the removal of the whole esophagus and advised closing the oral end. This procedure, however, is unpractical, as the closed end of the esophagus invariably leaks.

Küttner succeeded in removing a carcinoma of the upper thoracic portion of the neck by mobilizing the cervical and upper thoracic portions of the esophagus through an incision in the neck. He was able to pull the esophagus with the tumor out of the cervical wound and resect the tumor outside the body.

In 1912, Ash, independently and without the knowledge of Levy's work, succeeded in working out an ingenious method of extracting the whole esophagus, which he finally used in a case of carcinoma of the cardia which had extended upward into the intrathoracic part of the esophagus and downward to the stomach. The patient made an uneventful operative recovery, but, unfortunately, died of inanition in consequence of insufficiency of the gastric fistula. His patient is one of the few that recuperated fully after the operation. His procedure was as follows:

> The patient was turned partly on his right side. A large curved incision was made along the left costal border, starting at the ensiform process and extending backward. The rectus, obliquus externus and internus muscles were severed. The muscles were widely separated, especially posteriorly, in order that the left costal arch might be lifted upward. After careful hemostasis, the transversalis muscle and fascia were severed, and the peritoneal cavity entered. The left lobe of the liver was pushed over to the right, and the left costal arch lifted upward. This maneuver exposed the whole stomach and the cardia beautifully. The upper part of the stomach was involved by a large tumor, which seemed to have started at the cardia and extended over to the stomach. At the hiatus, the tumor could be distinctly felt involving the lower portion of the esophagus in a circular manner. The upper margin of the tumor could not be palpated through the diaphragm. As it seemed possible to remove the tumor, the abdominal cavity was temporarily tamponed. The cervical portion of the esophagus was then exposed by an incision, 8 cm. long, along the inner border of the sternocleidomastoid muscle. It was mobilized by blunt dissection, care being taken not to injure either recurrent nerve or the inferior thyroid artery. Preliminary packing of the wound in the neck followed. The patient was then put under differential pressure. Operation was continued from the abdomen. The tumor was pulled down a little, and the peritoneum was incised on the anterior surface near the hiatus. This incision was carried over to the serosa of the cardiac portion. The finger was then inserted into the hiatus, and the tumor was bluntly mobilized from the muscular portions of the

diaphragm, by working upward into the mediastinum with the finger. It was believed that the tumor surrounded the lower part of the thoracic portion of the esophagus to a distance of about 5 cm. After insertion of a Langenbeck hook into the hiatus, it was seen that the left vagus nerve was firmly embedded in the carcinomatous tumor. In trying to isolate the tumor on the right and left sides, both pleural cavities were opened.

On further mobilization of the tumor, posteriorly, the right vagus nerve was also found implicated in the disease process. In consequence of the manipulations necessary for the isolation of the esophagus and vagus, the pulse dropped to 44 per minute and became slightly irregular. In order to avoid further irritation of the vagi, both were cut through with scissors. No reaction on the part of the heart was noticed. The esophagus was clamped, 2 cm. above the tumor, and a ligature, about 1 meter long, was tied around the esophagus immediately above the clamp. The ends of this ligature were left long. The esophagus was pulled down farther; another clamp was placed immediately above the tumor, and the esophagus was divided between these two clamps. The upper stump of the esophagus was carefully wiped clean, and the lower stump, after the omentum minus and the left gastric artery had been tied, was displaced downward. The narcotizer then introduced into the esophagus a long flexible steel rod with an eye at its end. As soon as the steel rod was introduced, the operator grasped the lower end of the esophagus with his thumb and index finger, thereby being able to feel the rod distinctly through the walls of the esophagus. A suture was then passed through the wall of the esophagus and through the eye in the steel rod. This suture was left about 12 cm. long. By carefully withdrawing the steel rod from the esophagus, the walls of the esophagus were inverted, and the whole tube extracted until the lower esophageal stump appeared in the mouth of the patient. A small gauze compress was inserted into the mediastinum. Through the wound in the neck, one could see how the esophagus glided upward. The moment the lower invaginated end appeared directly above the jugulum, extraction was stopped. The long ligature which projected from the invaginated funnel was secured, and the fixation thread of the steel rod cut by the narcotizer. By pulling on the long ligation thread which projected from the neck, the invaginated portion was again disinvaginated through the neck wound. The skin over the sternum was undermined; an incision was made into the skin lower down and the esophagus pulled through this tunnel, and its lower end brought out of the skin wound so that it projected for about 2.5 cm. Tension on the esophagus was carefully avoided. A rubber tube was tied into the esophageal stump, and the wound in the neck was carefully closed, there being danger of pneumothorax. The tampon was then removed from the mediastinum, and there was practically no hemorrhage. The hiatus of the esophagus was closed by a running suture and buried, a second row of sutures catching up the peritoneum and a little of the muscular wall of the diaphragm to make the closure air-tight. This finished the removal of the esophagus. The tumor of the stomach was then resected; the stomach wound closed, and a gastrostomy established. The operation required one hour and twenty-five minutes.

Ach is of the opinion that his method can be successfully employed in carcinoma of the cardia and of the lower end of the esophagus up to 8 cm. above the diaphragm. Tumors which involve the upper thoracic portions, in the neighborhood of the bifurcation, must be attacked by an endothoracic operation, with a preliminary gastrostomy.

Rehn [11] repeated the method of extraction of the esophagus by invagination, after Ach. In two of his animals, there was a large hemorrhage into the mediastinum. In order to avoid this, he tried to invaginate only the mucous membrane of the esophageal tube, in which he easily succeeded. He tried the same method on the human being, however, without success, as the mucous membrane in man is not resistant enough. In his operations on human beings, he invaginated the esophagus in toto, downward and upward, and made the same observation as Levy, that in invagination downward, the outer longitudinal muscular coat stays behind. Contrary to Levy, however, he considers this a great advantage because it does away with the danger of mediastinal hemorrhage.

Since the advent of differential pressure, all of our endeavors to resect a tumor of the esophagus have been by the transpleural method. Although the advantage, so far as a good approach to the organ and ease in working are concerned, was great, the operation with its attending shock was so formidable that results were poor. The pleura is very sensitive to infections, and the irritation of the membrane during the long manipulations in the thoracic cavity produce powerful reflexes. To this is added the trauma to the lungs and their long exposure, which are weighty factors in the production of postoperative pneumonia. The complication of secondary pneumothorax as a result of the suture line not being air-tight is also a danger, although less great. It is undoubtedly true that, in great part, failures can be attributed to the following causes: infection of the pleura with consequent empyema, pyopneumothorax, pneumonia and postoperative shock. The last, however, can be successfully overcome, as numerous cases of my own and of others have shown. A good many patients have lived several days after the operation, and have finally succumbed to infection. A patient in whom thoracotomy has been performed, with exploration and closure of the thorax wounds, usually makes a good operative recovery, and then dies, many months later, of the disease itself. Air-tight drainage of the pleural cavity is demanded by many surgeons of experience, as Küttner, Willy Meyer, Tiegel and Mikulicz. Sauerbruch does not advise drainage, because he believes it hurts more than it helps. Torek's successful case was not drained. Rehn also recommends drainage in cases in which, during the operation, no direct infection has occurred, because the pleura reacts, in every case, with a fluid exudate which accumulates very quickly. On the other hand, drainage of the thoracic cavity is not irrelevant, as the drainage tube is a source of continued irritation and means a constant communication with the outside. Although we now

11. Rehn, Edward: Oesophagus-Chirurgie, Jena, G. Fischer, 1914.

have a number of air-tight drainage methods, they must all still be considered a disadvantage in intrapleural operations.

It is not surprising, therefore, that lately a number of surgeons have returned to extrapleural operations in carcinoma of the esophagus. Among them are Kummel,[12] Rehn, Levy [13] and, in this country, lately, Lilienthal.[14] Kummel has operated on eighteen patients with carcinoma of the esophagus. In nine cases, it involved the cardia, and, in nine cases, the thoracic portion of the organ. In consequence of theoretical consideration and experiments on the cadaver, he prefers the abdominal route for carcinoma of the cardia. He mobilizes the cardia in the hiatus, and the lower part of the esophagus as high up as possible, by blunt dissection with the finger. The cardia and the lower end of the esophagus were pulled down as far as possible, and the esophagus divided between clamps. After resection of the tumor, he tried to make an anastomosis between the esophagus and stomach. Under favorable conditions, he succeeded in pulling down 12 cm. of the esophagus, and on the cadaver, even 14 cm. His results, however, were not very encouraging on account of the insecurity of the suture. He had one operative success in a man who died one year later from metastases. In seven cases, the carcinoma was located in the thoracic portion, from 22 to 38 cm. from the teeth. According to the location of the tumor, operation is performed from the neck or by a large trap-door flap incision in the back, with resection of a number of ribs on the right or the left side of the vertebral column. In one case he mobilized the esophagus with the tumor and placed it outside the chest, sliding a skin flap under it with the idea of performing a plastic operation later. In cases of high intrathoracic carcinoma, he prefers the dorsal method, and, if possible, performed extrapleurally. An identical method was used in a patient operated on lately by Lilienthal, with a beautiful operative success.

Kummel, who has continued to work steadily on our problems, has lately published a method in which the entire esophagus is removed without opening the pleural cavity widely. The removed esophagus is replaced by the stomach, which is displaced from the abdominal cavity into the posterior mediastinum. The anastomosis between the esophagus and the stomach is made in the neck. In carcinoma of the cardia, he now proceeds as follows: The abdominal cavity is opened in the

12. Hauch: Ueber unsere Radikaloperationen beim Karzinom der Speiseröhre in ihrem thorakalen und abdominalen Abschnitt, Beitr. z. klin. Chir. **92**: 121, 1914.

13. Levy: Weitere Beiträge zur Resektion der Speiseröhre, Arch. f. klin. Chir. **119**, p. 20.

14. Lilienthal, Howard: Carcinoma of the Thoracic Oesophagus, Extrapleural Resection and Plastic, Ann. Surg. **74**:259 (Sept.) 1921.

median line. Marwedel's reflection of the costal border is rarely necessary. The cardia and the adjacent lower portion of the esophagus are mobilized, and the stomach is mobilized after the method of Kirschner.[15] An incision is made into the neck, and mobilization of the cervical and upper thoracic portions of the esophagus is accomplished by careful dissection with the finger. In a short thorax, he succeeded, in a relatively easy manner, by working with one hand in the neck and the other in the abdomen, in mobilizing the whole length of the esophagus in the posterior mediastinum. If the entire organ is not dissected loose by the method described, the last strands of tissue that hold the esophagus can easily be torn by a gentle pull. Then the esophagus and the mobilized stomach are pulled upward until the tumor projects through the neck wound, the stomach following. The new esophagus is formed by the stomach lying in the posterior mediastinum. A possible tear in the pleura is tamponed by the stomach and has no bad effect, as the operation is, of course, performed under differential pressure. The tumor is then resected and the stomach is anastomosed with the stump of the esophagus by suture or invagination outside the body. Kirschner's transposition of the stomach, replacing the esophagus and thereby changing the stomach into a functioning esophagus, means a great progress in the surgery of this organ. The great drawback heretofore was the anastomosis of the lower end of the esophagus and the jejunum, as originally advocated by Kirschner. The method as above described by Kümmel obviates this defect in Kirschner's procedure.

In cases in which the carcinoma is situated high in the thorax, Kümmel prefers, as do Rehn and others, the extrapleural dorsal approach. If the tumor proves operable, it is mobilized extrapleurally, downward and upward. After opening the abdomen, the stomach is mobilized according to Kirschner. At the same time, another operator dissects the esophagus in the neck; and the esophagus with the stomach is then pulled upward and out of the neck wound, the tumor resected, and the stomach and esophagus united. Closure of the abdomen and thorax is accomplished. In this fashion, any infection of the pleural cavity is avoided, and with it one great danger of these operations.

Kümmel has tried this method in many experiments on the cadaver and on animals. He also found it comparatively easy in one case in the human being, in which he performed it successfully and on which he promises a detailed report in the near future.

The whole operation seems to be a very bold procedure. I cannot help asking whether the complete transposition of the stomach into the posterior mediastinum can be borne without interfering with the func-

15. Kirschner: Ein neues Verfahren der Oesophagoplastik, Arch. f. klin. Chir. **114**:606, 1920.

tion of the heart and lungs when the stomach is dilated by the ingestion of food and by gas formation, thereby exerting pressure on the thoracic viscera. These, of course, are only theoretical doubts and scruples and cannot stand in the face of practical experience. However, in the light of our experience with the transposition of the stomach into the pleural cavity, there is a certain justification in raising such doubts. It may be that the stomach, placed extrapleurally in the mediastinum, behaves better than in the open pleural cavity.

Levy, in a late paper, also advocates the dorsal approach if possible, extrapleurally. In order to secure the necessary room, he removed the fourth to the tenth ribs from the angle to the costal cartilage, as Zaaijer recommended. He also describes a complicated extrapleural esophageal plastic operation.

SUMMARY

Surgery of the esophagus has passed through a long cycle of development, in which several distinct stages can be discerned: (1) extrapleural dorsal approach, with endeavors to reconstruct the lumen by suture; (2) transpleural approach under differential pressure, with an attempt to restore the tube, with or without transposition of the stomach, by suture or buttons of various types; (3) transpleural removal of the whole esophagus, placing the stump outside, from an incision in the neck and later reconstruction of the esophagus by a plastic operation according to the methods of Roux, Wullstein, Lexer, Hirsch, Jianu and others; (4) extrapleural removal of the entire esophagus by invagination (Ash, Rehn), by a combined method from the abdomen and the neck; (5) extrapleural removal by a combined method from the abdomen and neck, or from the abdomen, neck and back, with transposition of the stomach into the posterior mediastinum.

In 1895, Postemski summed up his conclusions about the indications for operations for carcinoma of the esophagus as follows: "There are operations which should not be tried, even on the animal, because failure is certain, and because they can never be applied to the human subject." (Il y a des operations qu' on ne doit pas essayer, même chez animaux, parce que l'insuccès est certain, et que l'application ne pourra jamais être faite chez l'homme.) Eighteen years have gone by since he uttered these hopeless words. Are they still true today?

We poor mortals must not make prophesies, but looking backward and scrutinizing our work, we are surely justified in taking a more hopeful attitude. It is true our results of today are not such that we should be boastful about them. So far, only in cases of carcinoma of the cardiac portion of the esophagus has the patient recuperated from the operation and lived. These cases were reported by Voelker, Bircher and Kümmel. Of carcinomas of the intrathoracic portion, only the patient of Torek, who is still alive and well after nine years, and that of Zaaijer have made full recoveries. In 1921, Lilienthal of New York

published the report of a case in which he succeeded in removing a carcinoma of the intrathoracic portion of the esophagus and restoring the lumen by a skin-flap plastic operation, by his posterior method. The patient later developed a recurrence and died. However, the dogged tenacity with which we have taken hold of this difficult problem bears the seed of ultimate success. Let us not tire; and I am sure that not many years from now many cures will have been accomplished in a disease that was beyond help and hope.

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POSTERIOR MEDIASTINOTOMY *

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Extrapleural posterior mediastinotomy is an operation which probably has a surgical value far greater than has been generally supposed. By the methods which I have worked out, the exposure is so complete that not only the posterior but also the middle and superior divisions of the mediastinum can be reached with facility and with comparative safety. The thoracic esophagus can be exposed, and operations on the portion between the lower limits of the aortic arch and the opening in the diaphragm can be safely performed in suitable cases; and, by enlarging the hiatus, it is not unlikely that the cardia may be drawn up within the retropleural space.

Suppurative infection of the mediastinum can be treated by drainage; enlarged lymph nodes and new growths can be reached; the bodies of the vertebrae can be exposed for operative procedures; the entire thoracic aorta can be examined visually, and, in certain not too advanced cases of aneurysm of this vessel, one can easily conceive of the carrying out of operative procedures hitherto considered too difficult for practice. I suggest, for example, the winding of not too extensive fusiform aneurysms of the descending portion of the aorta below the arch with fascia lata strips.

The phrenic nerves, the vagi, the left recurrent laryngeal nerves and the great splanchnics are within easy sight and touch. No doubt, pressure symptoms on one or another of these important structures will, in the future, be relieved by operation. Possibly, even tumors springing from the sympathetic system, such as the ganglion neuromas, may be attacked by this route instead of transpleurally. Finally, obstructing pressure on the thoracic duct may be relieved, or injuries to this important structure repaired.

The pericardium can be approached from behind, and procedures on this remote part can be carried out without dislocating the heart.

Until the present time, mediastinotomy has been a most unusual operation. In the near future, it will become comparatively common. The development of the surgery of this region will present a fascinating series of problems in physiology, in pathology, in diagnosis, including roentgenology, in operative technic, in drainage and in the healing of wounds. As our experience enlarges, timidity will give place to confidence, and gradually our brothers who practice internal medicine will

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send us their patients, not as a last resort, but in the reasonable hope that we may accomplish something for them.

Until 1921, there were described only two methods of entering and exploring the posterior mediastinum without deliberately violating the pleura: first, that of Nasiloff,[1] who resected a number of ribs posteriorly and reached the mediastinum through this opening; second, that of Bryant, who made a trap-door of ribs and soft parts, swinging on a sagittal hinge and exposing a quadrilateral opening with rigid sides and a definitely limited area; and later Enderlen[2] made a similar trap-door but resected the ribs. What little retraction was possible in these operations depended on the spring of the anterior portion of the divided ribs on their cartilages while the upper and lower undivided ribs acted as a bar to the lateral spreading of the wound. Also, in gaining access to the posterior mediastinal space, the scapula would have to be dissected away and ribs resected beneath it.

AUTHOR'S TECHNIC

The principle on which this approach depends is that of the retraction of the divided ribs at right angles to their long direction, shingling them, one upon the other, thus making the deep exposure from below upward, the extent of available space being determined by the length of the wound, especially that portion which divides the intercostal extrapleural structures.

Preparation.—In addition to the general examination of the patient in order to determine his fitness to withstand an operation, the blood pressure should be ascertained, and, if the systolic is lower than 125, digitalis should be administered for the twenty-four hours before operating. A tincture of standard potency in doses of from 15 to 30 minims, every four hours, should accomplish digitalization in a day.

Position on the Table.—The patient should lie on the right side, but turned about 30 degrees toward the front so as to bring the field of operation into the most convenient position for the surgeon. The thighs should be flexed and held by straps passed under the table. The right arm may be slightly behind the patient, the left arm drawn forward and a little upward. The position of the body must be maintained by means of large sand pillows. A pillow or the bridge of the operating table will raise the body into the position of a moderate scoliosis.

Anesthesia.—Ether or nitrous oxid and oxygen, or a combination or sequence of two or more, when skilfully administered will give a

1. Nasiloff: Vrach. **9**:481, 1888.

2. Enderlen: Ein Beitrag zur Chirurgie des hinteren Mediastinum, Deutsch. Ztschr. f. Chir. **61**:441, 1901. Enderlen, Hotz and Porzelt: Beiträge zur Chirurgie des Oesophagus, Ztschr. f. d. ges. exper. Med. **3**:108, 1914.

quiet, safe narcosis, though I have fully exposed the mediastinum with local anesthesia without the slightest expression of pain by the patient until the sensitive nervi vasorum of the aortic sheath were manipulated. If a general anesthetic is used, preparations must be made for the immediate application of differential pressure, for there is danger that both sides of the chest may be opened when stripping the pleura forward. At the level of the eighth and ninth dorsal vertebrae, the right pleura often sends a fold across the median line for an inch or more into the left chest, and, if the left pleura has been accidentally torn and the right is also opened, death will quickly follow unless there is positive pressure in the air passages or negative pressure at the wound. If neither pleural sac is injured, ordinary inhalation narcosis is all that is necessary.

Operative Procedure in Low Posterior Mediastinotomy.—An incision is made on the ninth rib, beginning 7 or 8 inches (17.7 or 20 cm.) from the spine and running backward along the rib to the edge of the long spinal muscles, then curving upward, parallel with the spine for four or five interspaces. The ninth rib is resected subperiosteally as far as the wound will permit, beginning just anterior to the angle. But the mere reaching of the posterior mediastinal space can be accomplished with a much shorter resection, or possibly even by merely dividing the rib. The normal pleura is extremely thin and will tear unless the greatest care is exercised. When the resection is complete, the finger is inserted slowly between the posterior unresected part of the rib and its periosteum, peeling this membrane and the pleura forward, away from the posterior chest wall. In this region, the attachment of the pleura to the parietes is much less intimate than it is more anteriorly, so the stripping is easier. Soon the pleura will be found to have separated from the eighth rib, and this bone can be divided with powerful cutting forceps while the finger passed under the rib acts as a guard. The pleura, beneath which the lung can be seen gliding smoothly, is then worked still farther forward, two or three fingers of the right hand being used for the purpose, and the seventh rib is treated as was the eighth. The stripping becomes easier, and often the pleura literally falls away from the mediastinum, especially in the upper part. As many of the next upper ribs as may be required for the exposure are then divided close to the spine, and the pleura and lung are peeled forward with increasing gentleness until it appears that enough space has been made. With a broad blunt retractor against the lower edge of the eighth rib, a firm pull is exerted at right angles to this structure, and the first landmark to come into view will be the great splanchnic nerve, as it lies on the posterior chest wall part way up the elevation formed by the bodies of the vertebrae. When the pleura is pressed still farther forward, the descending aorta is felt and is next laid bare, together with

the left part of the vertebral bodies which are covered with fascia. In front, we now have the esophagus with the pneumogastric nerves, the right, more posterior one, being easier to locate. The recognition of the esophagus by sight or touch is not easy, even when a good sized stomach tube has been inserted through the mouth as a guide. I have, therefore, devised a diaphane which consists of a rubber tube, from 32 to 40 caliber, into the end of which is fitted a little electric lamp, the wires passing through the tube to a small hand battery. An assistant passes this into the esophagus through the mouth, and the light, on being flashed, shows through the tissues with a bright crimson glow, instantly indicating the location of the lumen of the organ. The esophagus is nearly always carried forward with the pleura and pulmonary ligament, much as the ureter is drawn forward with the peritoneum.

There is a netlike layer of tissue which holds the esophagus and the descending aorta together and is continuous with the adventitia of the artery and probably with the pulmonary ligament. This may be lifted from the vessel with forceps, divided with scissors, and partly stripped away to facilitate orientation of the esophagus. But rolling the aorta from its position is dangerous, for its intercostal branches on the far side may be torn, and the resulting hemorrhage may be difficult to control. In one of my cases, the aorta, an extremely thin-walled specimen, was torn by forceps in attempting to check bleeding of this kind, with a fatal result.

In exposing the esophagus, the two principal points are to guard against vagus shock and to avoid entering the pleura. The vagus may be temporarily blocked, as advised by Torek, by applying to this region, above the place where we are dissecting, a little 5 per cent. cocain on a cotton pledget. To keep the pleura intact, we must be most gentle in our manipulation, and every effort must be made to identify the right pleural reflection. The esophagus is not covered by a glistening coat as are the normal intestines, but its outer layer consists of muscle which can too easily be torn by rough handling, and the lumen of the esophagus accidentally entered. The right, more posterior, vagus, with its plexus gulae, is quickly identified, and the nerve branches of the plexus can be divided with scissors if it is desired to isolate the esophagus. The left vagus is not usually seen. With a large broad retractor, the pleura and lung can then be drawn aside, and the posterior wall of the pericardium exposed.

Freeing the esophagus downward, we may follow it forward with its accompanying nerves to where it passes freely through the hiatus in the diaphragm. But it is not easy or always possible to peel the pleura away from the central portion of the diaphragm.

The High Operation.—With this procedure, the upper portion of the posterior mediastinum is entered and much of the superior space

is exposed. It is carried out on the same general plan as the operation just described, but it is the seventh or even the sixth rib which is first resected, and the fifth, fourth and third are divided posteriorly. At this level, the approach may be from right or left. The trapezius and rhomboid muscles are cut, and the scapula drawn far forward. The separation of the pleura from the chest wall is distinctly easier than it is below, and this sac, with its contained lung, may be pressed downward from the superior opening of the thorax, exposing the entire aortic arch with its branches. The trachea and its bifurcation, the esophagus and the other structures of this region can be seen and handled with facility. We are now operating above the cardiac branches of the vagus, so the cocainization of the pneumogastrics is more important here than it is below.

The left side appears to be the more suitable avenue of approach in opening the lower part of the posterior mediastinum because the aorta, which is the main landmark, lies first to the left of the bodies of the vertebrae, and gradually works over toward the median line, which it almost reaches at a horizontal plane which passes through the tenth rib at the place where it joins the spine. The esophagus in the upper part of the thorax is toward the right of the aorta but comes more directly in front of it as the artery swings toward the midline. Approaching from the left, also, we find that the pleura of this side does not have the complicating fold which is found on the right where, as mentioned above, the sac often crosses to the left side. In pushing the pleura forward after the esophagus is reached, the pulmonary ligament is torn. To the operator, this ligament, in this part of the operation, is not in evidence and it appears to him as if the pleura were pushed directly away from the esophagus. As a matter of fact, of course, the pulmonary ligament is bluntly divided, although it is not usually identified. If the right pleural process should happen to be torn, there will be an immediate and audible rush of air into the right pleura, and it is at this time that differential positive pressure must be applied, which, as stated above, is all the more important if a hole has been torn in the left pleura as well. This accident occurred twice in my experience. One of the cases is worth reporting briefly, a complete record having been published previously.[3] During a dissection in a case which proved to be an inoperable cancer of the esophagus, I was attempting to isolate the normal part of the gullet when the right pleural process was torn. There was a sound of rushing air, and the heart's action became very irregular. The left pleura, which was fragile, had been already torn, and intrapharyngeal pressure had to be applied. Cyanosis, however, occurred, with extremely shallow

3. Lilienthal, Howard: Ann. Surg. **74**:259 (Sept.) 1921.

breathing, and I thought that a fatality on the table was imminent. The chest was quickly and completely closed, and the patient recovered so that he left the table in good condition, dying, however, forty-eight hours later. A postmortem wound inspection revealed air and a little bloody serum in the right pleura. It is probable that death was caused by pneumatic and circulatory changes in both sides of the chest in an old and cachectic patient.

I have explored the posterior mediastinum eleven times for carcinoma of the esophagus, and some of the histories have been reported.[3] I have twice explored the superior mediastinum, together with the upper part of the posterior. In both, exposure was perfectly satisfactory, and the mediastinotomy itself was not so difficult as in the lower operation. The arch of the aorta and its branches, particularly those on the left side, were perfectly exposed. Both operations were through left-sided incisions.

The accidental entry into one pleural sac does not necessarily mean that the operation must be immediately abandoned. With the aid of differential air pressure, the procedure may be continued, and at its termination, if the wound in the pleura is too large for suture or if the pleura is too fragile to hold the stitches, a covering of gauze or of rubber dam may be laid on the rent, the remainder of the mediastinum packed and the external wound closed. In a few days, the lung will have expanded and will have sealed off the rent in the pleura. I first observed this in the case of a woman, aged 63, who had a carcinoma of the esophagus just below the aortic arch. There was also a large metastasis in the right upper pulmonary lobe, which had unfortunately been misinterpreted in examining the roentgenogram. In this case, I found, near the end of the operation, that there was an opening in the pleura, half as large as the palm of an adult hand. The flap of the skin which was to have been used to form a new esophagus was laid inaccurately over this large opening and held in place with three or four catgut sutures, and the mediastinum packed. Under the packings, granulation set in, and the chest became sealed off. The patient unfortunately died, eleven days after operation, of what appeared to be a heart block or a vagus disturbance.

A postmortem wound inspection revealed the left lung fully expanded and adherent to the location of the rent in the pleura. Indeed, the adhesion was so firm that, on removing the flap of skin, the pleura was still thoroughly airtight and the lung completely filled the cavity.

I have had but one opportunity to perform posterior mediastinotomy in a condition other than carcinoma of the esophagus, although I have entered this space transpleurally a number of times.

REPORT OF CASE

History.—A. P., a man, aged 43, for two months had suffered with pain in the dorsal region, with cough and expectoration and with pain beneath the sternum. There were râles in the right base. Roentgenograms revealed a dense shadow in the interlobar region or in the middle lobe on the right side and over the dome of the liver. There were also shadows at the right hilum. No tubercle bacilli were present in the sputum. The Wassermann blood examination proved negative, three times. Later roentgen-ray examinations revealed a dense mass, apparently in the mediastinum, from the tenth rib up to the fourth, more marked on the left side. There was no fever when I first saw him in the early part of May, 1921. The pain was extreme and was localized in the middorsal region, requiring large doses of morphin for its control. Physical signs at that time indicated râles in both bases and increased voice conduction in the right middle posterior chest. The patient entered the Flower Hospital Private Pavilion, and, May 23, a semilateral roentgenogram, as well as a fluoroscopic examination indicated that the tumor of the mediastinum was continuous with that of the lung and that the greatest density was at the ninth rib, posteriorily. The next day, I operated, Dr. Neuhof assisting. The anesthesia was by gas, oxygen and ether.

Operation.—The patient lay on his left side in the position of scoliosis. A long incision was made over the right ninth rib, and this rib was subperiosteally resected for about 6 inches (15 cm.), with resection, posteriorly, of the eighth and seventh ribs as well. The pleura was easily stripped away from the ribs and from the posterior chest wall, with excellent exposure of the entire posterior mediastinum, but no tumor was found. The mediastinum was packed with gauze, and the pleura at once freely incised and its contents exposed. The lower portion of the upper pulmonary lobe contained a large dusky mass, giving the impression of a neoplasm. A specimen was removed for diagnosis, and about 30 drops of nonodorus pus exuded. We were evidently dealing with an indurative suppuration in the lung, probably secondary to an infected tumor. There was a small elastic bulging mass on the anterior surface of the body of one of the vertebrae; this was punctured with the needle. It bled freely, but no pus was found. The opening in the lung was packed with gauze, which was led out posteriorly. The greater part of the wound was then closed with two pericostal chromicized catgut sutures and a number of interrupted muscle sutures of the same material. The skin was left open and a packing left in the mediastinum. Just before tying the last suture to close the pleura, the lungs were inflated and the chest was closed airtight.

Pathologic Report (Dr. Mandlebaum).—The specimen revealed an interstitial inflammatory process, with a purulent inflammation which was evidently superimposed. Nothing was present to suggest neoplasm.

Course.—No general empyema resulted, although there was some suppuration in the chest wall, and part of the wound was opened wide for drainage. Ten days after the operation, the packings were gradually removed from the mediastinum, and there was only a mild infection. The packing in the lung cavity was replaced by a soft rubber tube. The temperature rarely reached more than 102 F. The pain in the back was completely relieved, and, for a time, it looked as if the man would recover. Indeed, a few weeks later, the wound in the thorax had closed to a small, slightly discharging sinus, when a gradually increasing left hemiplegia appeared, with delirium, and the patient died. Most unfortunately, no necropsy was permitted, but it is probable that he died of a cerebral metastasic abscess.

COMMENT

This case illustrates how simple a matter it is to make a complete exploration of the posterior mediastinum by this method and how safe from infection such an operation may be, probably because of the ample drainage, for there was no mediastinitis in spite of the neighboring abscess. It is also interesting to note the complete relief of pain in the back which this operation afforded. It was like a true decompression.

Another case, the first to my knowledge in which this method of approach was used in a suppurative mediastinitis, was that of a woman, in the practice of Dr. Harold Neuhof. Here, there occurred high fever and severe dorsal pain, with dulness on percussion in the right lower back running up along both sides of the spine. Remarkable bedside roentgenograms demonstrate: first, the value of roentgenography in making a diagnosis of posterior mediastinitis, and, second, the change in the roentgen-ray appearances following the operation and the evacuation of pus from the mediastinum. Dr. Neuhof stated that the procedure was easy and that injury to the pleura was avoided without difficulty. The patient recovered.

CONCLUSIONS

Although this report of experience in posterior mediastinotomy is limited, I believe it indicates the surgical value of the procedure. As a means of exploration, it ranks with wide intercostal thoracotomy, and is probably more complete than exploratory laparotomy. I believe it will eventually become one of our standard operations and that more successful results will follow earlier intervention. Articles which practically cover the field of posterior mediastinotomy, including the approach to the esophagus, are those by Kirschner [4] and by Rehn.[5] Enderlen's paper is also important.

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4. Kirschner: Oesophagus Chirurgie, Arch. f. klin. Chir. **24**:606, 1920.

5. Rehn, E.: Operationen an dem Brustabschnitt der Speiserähre, Arch. f. klin. Chir. **57**:733, 1898.

TERATOMA OF THE RIGHT CHEST CAVITY

REPORT OF CASE *

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History.—Jan. 23, 1922, a boy, aged 15 years, entered the Massachusetts General Hospital with the diagnosis of dermoid cyst of the right pleural cavity. The father had died of what was probably consumption. Otherwise the family history was negative. The patient had had measles and pertussis. He had never been robust, but otherwise the past history was negative.

During November and December, 1920, that is, fourteen and fifteen months before entrance to the hospital, the patient was rather below par and occasionally complained of pain in the left side of the chest. He played about as usual, however, until January, 1921, when he began to cough a little and had some fever. The local physician thought he had fluid in the chest and sent him to the Newburyport hospital with the diagnosis of "sero-fibrinous pleurisy," where he was admitted, Jan. 31, 1921. Examination revealed dulness at the right apex and flatness over all that base below the angle of the scapula. The roentgenographic examination revealed "dulness as high as the fourth space, which did not shift on changing position. The roentgen-ray diagnosis was encapsulated empyema or malignant disease." The patient was discharged February 11, twelve days after entrance, without operative treatment, and somewhat improved.

Subsequently he felt fairly well for nine months, but remained in bed part of the time, and got out of breath if he played much. He believed he gained some weight during this time. He coughed very little; but occasionally there was a little blood-tinged sputum. He had rather frequent gas pains and vomited with indiscretions of diet. In December, 1921, he began to have some pain in the right side of the chest, and, Jan. 5, 1922, he was again admitted to the Newburyport hospital. There, examination was much the same as that noted later when the patient entered the Massachusetts General Hospital. The roentgen-ray at that time disclosed "a dense shadow extending to the top of the third rib, showing some increase in size from the previous year." A No. 14 catheter was introduced through a trocar, and 4 ounces (118.4 c.c.) of colloidal jelly was aspirated, with considerable suction. This material contained numerous hairs, from one-half to three-fourths inch (from 12.7 to 19 mm.) in length. The report of the pathologic examination of this material, made at the Harvard Medical School, was as follows: "Brownish, extremely viscid liquid containing many white flakes, from 1 to several millimeters in diameter, which have a pearly iridescence. These prove to be made up of keratinized epithelial cells. There are also many hairs free and embedded in the epithelial scales. Diagnosis: Material from dermoid cyst."

About two weeks later, Jan. 23, 1922, he was admitted to the wards of the Massachusetts General Hospital without any appreciable change in condition.

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* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

Examination.—This revealed a rather underdeveloped and distinctly undernourished boy of 15 who did not appear to be more than 11 or 12. The thorax showed marked asymmetry, the left side of the chest being thin and flattened, while the right side was rounded and bulging, the bulging being much more marked at the costal border than at the apex, and much more noticeable in front than behind. The right side of the chest was practically fixed on respiration. The

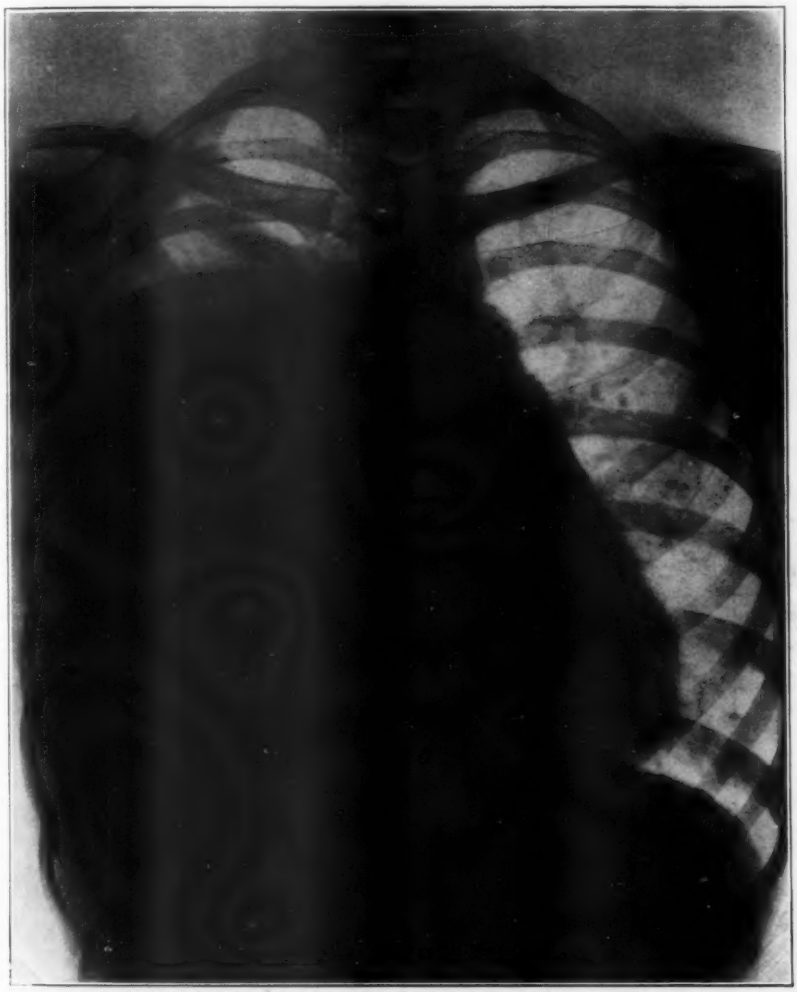


Fig. 1.—Tumor occupying the right pleural cavity.

left lung was resonant throughout, with exaggerated vesicular breathing, while on the right, the entire chest was flat, with absent breath sounds, except for a small area at the apex where breath sounds were transmitted feebly. Tactile fremitus and whispered voice sounds were absent everywhere on the right, except at the apex. Cardiac impulse was visible in the fourth, fifth and sixth interspaces on the left. Maximum impulse was seen and felt,

5 cm. outside the nipple line. Sounds were normal without murmurs or thrills. Blood pressure was systolic, 95, diastolic, 60. The liver border was palpable, 5 cm. below the costal margin in the right nipple line. The fingers of both hands showed moderate clubbing. The toes showed none. Examination otherwise was negative.

Laboratory Examinations.—The urine and stools were normal. The sputum was small in amount, watery, brownish and contained staphylococci, short

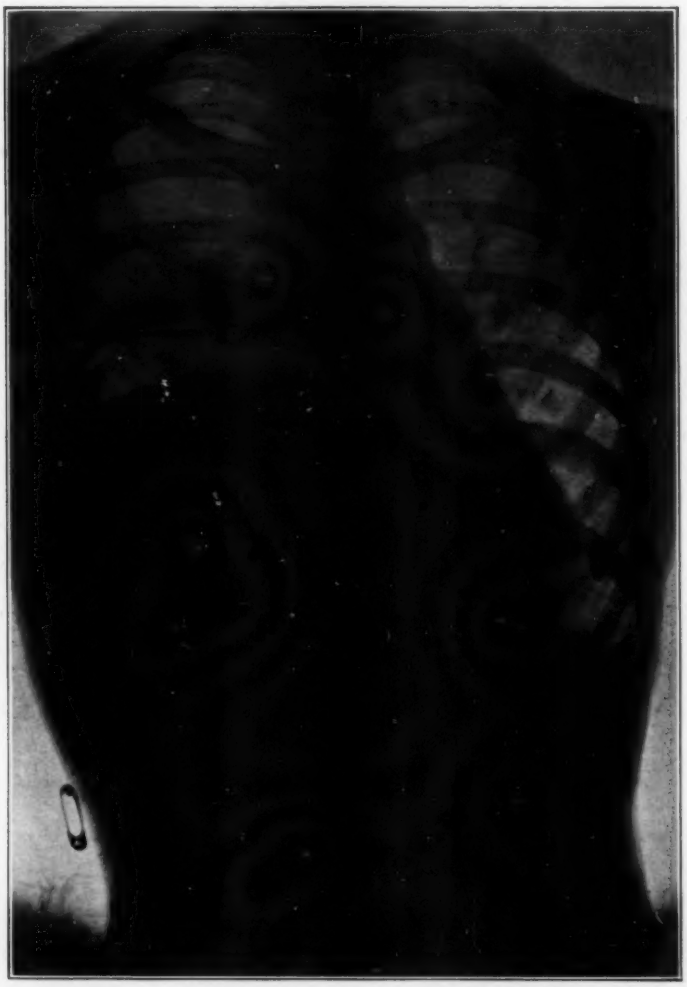


Fig. 2.—No evidence of expansion of lung; fluid level in the pleural cavity, seventeen days after operation.

chained streptococci and diplococci. Blood examination revealed: leukocytes, 10,500; erythrocytes, 5,130,000; platelets, normal; hemoglobin, 70 per cent.; differential count: polymorphonuclears, 74 per cent.; lymphocytes, 23 per cent.; transitionals, 2 per cent. The red blood cells were normal. The patient belonged to blood Group IV.

Fluoroscopic Examination.—"The entire right chest, except the apex, is occupied by a dense shadow with an indefinite upper border. The right diaphragm and the costophrenic sinus are both obscured. No fluid level is observed. The heart is displaced to the left. The roentgenogram confirms these findings (Fig. 1). Dulness in the right chest extends to the second rib. The appearance suggests an extensive pathologic process in the right chest, involving the lung, with possibly the presence of fluid."

Operation and Result.—Feb. 1, 1922, an operation was performed. It was started under paravertebral anesthesia; but, as the patient soon became restless and hard to manage, gas oxygen was given and the operation completed under this. A section of the sixth rib, measuring nearly 8 inches (20.3 cm.) was removed, and the chest cavity opened. A very large solid tumor appeared, and, in order to expose this, the fifth, seventh and eighth ribs were cut across,

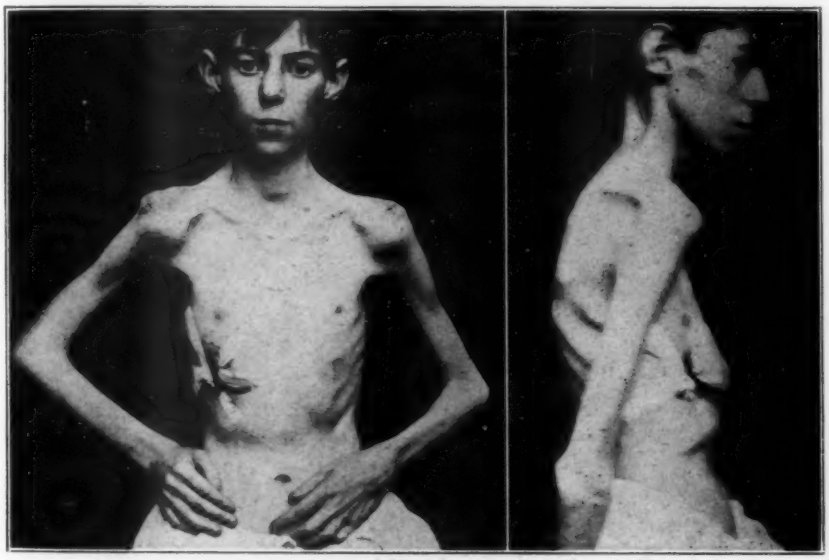


Fig. 3.—Left, patient after operation, showing drainage tube still in place; right, bulging of the lower part of the chest, the same as before operation.

close to the vertebral column. These were spread wide apart, giving an excellent exposure. The tumor extended from the diaphragm to the second rib and was very adherent. The whole right lung was pushed up into the apex of the chest. The tumor was removed, with considerable difficulty, as no definite line of cleavage could be found. There was a pedicle containing several large blood vessels that seemed to have its origin in the mediastinum. After delivering the tumor, the lung was carefully examined. It was little larger than the palm of one's hand, being divided into three lobes. The middle and lower lobes were of about the same consistency as the liver and were a dark brown. The apex of the upper lobe was soft, grayish white and had a very little air in it. The oozing inside the chest cavity was stopped, and the wound sutured tight, with a catheter, which was kept shut off, in the lower end. During the operation, the patient's blood pressure dropped from systolic 95, diastolic 60, to systolic 50, diastolic 30, and the pulse became

slower and slower so that at the end of the operation it was only 50, this probably being due to irritation of the vagus nerve during the removal of the tumor. He was transfused while still on the operating table, although no large amount of blood had been lost. This improved his general condition.

Within twenty-four hours after operation, the patient's pulse gradually increased to 140 and the blood pressure was systolic 85, diastolic 40. Large amounts of bloody fluid were aspirated through the catheter, at first every hour and later every two hours. Nothing taken by mouth was retained during the first three days, and fluids were kept up by means of rectal and intravenous glucose injections. By the fourth day, the patient felt so well that he kept sitting up in bed unless restrained. On the morning of the fourth day, when I

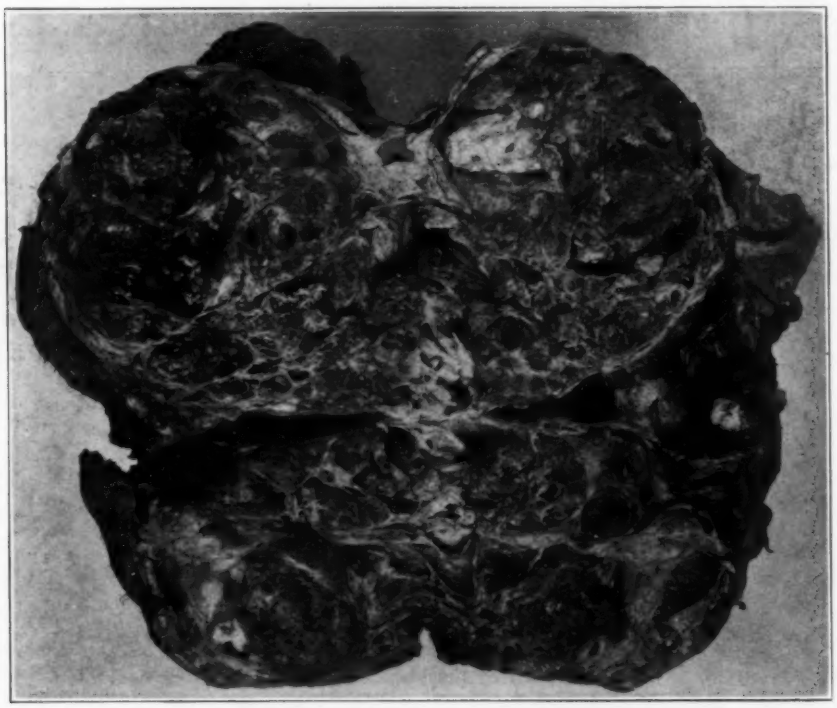


Fig. 4.—Tumor split wide open.

made my visit, he was reading the morning paper. On the eighth day, the catheter was removed, and the sinus was allowed to close, as we could no longer obtain any serum from the cavity with suction. The rest of the wound healed by first intention.

The patient's temperature remained normal for three days, and then the temperature ran a mild septic course, probably from absorption of reaccumulated fluid in the chest cavity. This gave him no discomfort and little constitutional reaction other than the rise in temperaure. A roentgenogram, taken February 18, eighteen days after operation, revealed: "Considerable fluid in the lower half of the right chest and no evidence of expansion of the lung." The right side of the chest was tapped with a needle and aspirated several times, from 2 to 8 ounces (from 59 to 236 c.c.) of a dark brown fluid being

obtained (Fig. 2). This fluid contained practically no leukocytes, and a culture was sterile. He gained strength slowly, but continued to have a septic temperature.

March 7, thirty-five days after operation, fluid aspirated from the chest was found to contain many leukocytes, and the culture showed staphylococci. A No. 20 catheter was reinserted in the old sinus at the lower end of the incision, and a large amount of pus was aspirated. The cavity was kept fairly clean with irrigations of salt solution, and, although he continued to have a low septic temperature, his general condition improved very much, and he was discharged to his local physician, March 22, fifty days after operation.

COMMENT

Figure 3 shows the appearance of the patient at the time of discharge. The illustration to the right shows the bulging and rounded appearance of the chest, especially at the costal border, as described in the physical examination. This still persisted after operation.

Pathologic examination revealed a cystic and solid tumor about the size of a large cantaloup, measuring 8 by 13 by 17 cm., and weighing 1,491 gm. It had a thick capsule, with redundant folds, containing several nodules about the size of an English walnut. These folds evidently represented the collapsed walls of a cyst. On section, it was honeycombed with small cysts filled with thick, white, tenacious fluid. Some of them showed black pigment. There were areas of bony plates and epidermis. Some of the cysts were filled with necrotic material, in which hair could be identified. Microscopic examination disclosed stratified epithelium, with sebaceous glands and hair follicles, smooth muscle and myxomatous connective tissue, sympathetic ganglion cells and nerve fibrils, tubules suggesting the spinal canal, fragments of deeply pigmented epithelium suggesting retina, tubules lined by epithelium suggesting the intestine, and groups of small tubules filled with eosin-staining material, suggesting the thyroid. The diagnosis was teratoma (Fig. 5).

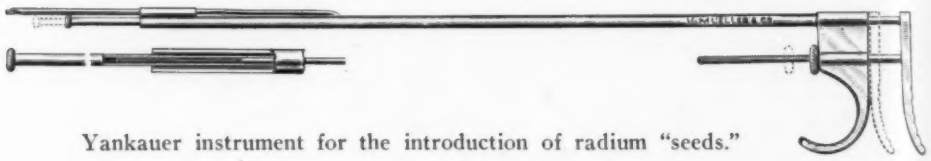
Although this boy survived the operation and left the hospital in fairly good condition, it was disappointing to find that the lung showed no tendency to expand. At operation, pressure from the gas oxygen machine had no effect on making the lung expand, and breathing exercises following the operation produced no expansion. At operation, the only evidence found of air having entered the lung was at the apex of the upper lobe. The rest of the lung appeared to be undeveloped and infantile, thus the inability to make it expand was not unexpected.

A RADIUM NEEDLE FOR THE ESOPHAGOSCOPE*

SIDNEY YANKAUER, M.D.
NEW YORK

The instrument here presented is intended for the introduction of glass capillaries containing radium emanations (the so-called radium seeds) into the tumors of the esophagus.

In introducing radium seeds into readily accessible tumors, it is customary to introduce the needle and then withdraw it a short distance before ejecting the seed, so that the seed travels in a previously made channel. I have found, after several trials, that the emplacement of the seeds in a tumor of the esophagus through the esophagoscope cannot be accomplished with precision, because the tumor, as well as



Yankauer instrument for the introduction of radium "seeds."

the esophagoscope, are in constant motion, but they do not move together. The position of the instrument cannot be controlled with any degree of accuracy.

To overcome the difficulty, I have constructed an instrument with an adjustable stop by means of which the depth of penetration of the needle can be previously fixed. When held firmly against the tumor with the handle closed, the stylet and the seed are held immovable and the needle is withdrawn, leaving the seed in the channel made by the needle.

In actual use, the introduction of the seeds proceeds quickly and with accuracy.

The instrument is made by V. Mueller and Company, Chicago.

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* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

SURGERY OF THE MEDIASTINUM, INCLUDING THE HEART AND ESOPHAGUS

ABSTRACT OF DISCUSSION

Dr. Edward W. Archibald, Montreal, Canada: Our President remarked that the treatment of pulmonary tuberculosis was entering a new phase, with Sauerbruch's posterior extrathoracoplastic operation. It is perhaps the only branch of thoracic surgery with which I feel familiar. I can only say with regard to my own experience, which now numbers fifteen cases, that the results have been very gratifying, on the whole. They approximate those of Sauerbruch, with practical cures of from 25 to 35 per cent. of the patients. It is our duty individually and as a society to make ourselves familiar with this particular branch of thoracic surgery, because I know of no other branch in thoracic surgery which really promises more; not only that, but there is no other branch of surgery in which our duty from the social and economic point of view is more clear. We all felt last year in Toronto when Dr. Lilienthal read his paper on the posterior mediastinal approach and resection of the esophagus that here was a strong ray of light. Heretofore, we all had been pessimistic in regard to resection. I remember going over statistics and finding twenty patients operated on since 1910, and only one living! It seemed that Dr. Lilienthal had not only solved the problem, but had devised a means of avoiding the danger of infection. These patients usually died of mediastinitis. By using two stages in his technic, he bade fair to overcome this difficulty, because we all know the defensive power of granulation tissue. Dr. Armstrong spoke to me last summer in reference to a case of esophageal cancer and asked me whether I would like to take care of the patient. The woman was middle aged; the symptoms of obstruction had been present for several months; she could still swallow fluids, just enough to maintain a moderate degree of nourishment, but her general condition was good on the whole. She was treated with preliminary irradiation. Esophagoscopy had revealed a cancer just above the arch of the aorta; quite a little higher than that in the successful case reported by Dr. Lilienthal last year. It was obvious that we had to do something. I could not agree with Dr. Lilienthal that a primary gastrostomy was unnecessary. It seems to me that a primary gastrostomy is advisable. You have to get these patients into better condition. I performed a gastrostomy, and, after waiting about three weeks, the patient was in a fair state of nutrition and I proceeded with the operation. I removed two ribs, the sixth and seventh, bringing the scapula upward and outward in order to give myself more room. Dr. Lilienthal says it is not necessary. I dare say it is not. I went in from the right side. I felt that I would not be bothered by the pericardium and that I would have more room. The first thing I discovered was that the pleura was difficult to separate. Dr. Lilienthal tells us this morning that it is because one does not go about it in the right way. I dare say that is true, but I cannot see just how I failed to go about it in the right way. I found great difficulty in separating the thin pleura without tearing it. Wherever I worked, it seemed so adherent that I had to proceed with the greatest caution. This was particularly the case when I reached the spinal column where it tore in several places. I had the patient under positive pressure. I am sure I tore through the pleura in places where

it was difficult to see, and, as a matter of fact, although I repaired everything, as I thought, I ultimately caused some pneumothorax which was sealed by positive pressure during the operation but which made itself evident after operation. Then came trouble by reason of the adhesions of the tumor itself to the posterior mediastinum. I separated the adhesions with difficulty. I cannot say how much the adhesions were due to radium and how much to the tumor. I had no trouble from the vagus, and there was no particular shock. I was able to isolate the tumor and to excise it. It was a hard growth, about 1 inch (2.5 cm.) in length. I was able to feel the esophagus with the stomach tube quite easily. Difficulties arose after the operation. Since the skin flap was long, it became gangrenous at the edge—about one-fourth to one-half inch from its tip. Symptoms of moderate pneumothorax, evidenced by slight mediastinal flutter, were obvious. They were quite certainly due to tearing of the pleura, which had not been sutured. Infection developed, and the patient died on the sixth day, of what I consider to be a mediastinitis proceeding from infection and gangrene of the flap, combined with a partial pneumothorax on the right side. Such was the result! Now, then, to summarize: The points that I should like to make are that the dangers are still there, I believe. The great optimism with which we welcomed Dr. Lilienthal's paper should be modified, not with Dr. Lilienthal as the operator, but with me as the operator. The difficulty of loosening the pleura is still there, to my mind. I cannot see how "the pleura just falls away." I have seen cases in which it falls away, but it does not always do so. The danger of infection is still there. In order to avoid it, I made the flap just a trifle too long, longer than necessary. I believe one should go a little deeper and include the deep fascia and muscles. If you include the muscles at the base, with the deep fascia, I believe, perhaps, that feature would be minimized. The high situation of the growth did not seem to offer any appreciably greater difficulties to exposure than the lower situation of the growth. As I said, I found no particular vagus effects. These cases are different from those in animals. We have listened to Dr. Fischer's paper with great interest. Experimental work in animals is comparatively easy. In the human being, we shall always have adhesions which cause a great deal of difficulty. The operation itself was not particularly shock producing; there was never any moment in which I was afraid. I merely present the report as a contribution to the subject, pointing out the difficulties I have met. I, nevertheless, still believe that this method is the only rational method for such cases and do not wish this report to be taken as a deterrent. It will not be a deterrent to me, but, nevertheless, I believe we should be prepared for a little more difficulty than Dr. Lilienthal led us to expect in his paper this morning.

Dr. Leon T. LeWald, New York City: I have had an opportunity to study roentgenologically four cases of mediastinal tumors, resembling closely the type described by Dr. Whittemore. My four cases, curiously enough, were all on the left side. Dr. Whittemore's happened to be on the right. The first case was thought to be an aneurysm; but, after prolonged study, we could not detect expansile pulsation; we could distinguish a slight separation from the heart and aortic shadows sufficient to make us believe it did not originate from them, although closely attached to the pericardium. This patient was not operated on. We watched him for about a year. The tumor increased slightly in size, or at least it did not increase materially, as the aneurysm would have been expected to do. We lost sight of the patient, until two years later, when, on looking up the history, the outcome of the case was found to be as follows:

The patient had a spontaneous evacuation of the contents of this probable cyst. At the time we saw him he was at St. Luke's Hospital, and two years later in the Presbyterian Hospital, with what was supposed to be influenza. He had a violent attack of coughing, and rather thick material was coughed up. The nature of this material, unfortunately, was not definitely determined pathologically. The man made a complete recovery, and, when we heard from him two years later, he was absolutely well. We believe it was a tumor of this character spontaneously evacuated. The second case was in a boy of 19. The shadow apparently represented a tumor of a simliar nature. This young man we observed for three years, and the tumor increased in size, coming almost to the surface of the chest. At that time, we hoped to have him admitted for an exploratory thoracotomy. He, however, was one of the boys about the streets of New York and was not very faithful about returning. I have no further record of his case. The increase in size of the mass in a boy, 19 years of age, was of considerable interest, and would, I think, fit in with this type of tumor, if it were a dermoid. The case is of further interest because of the constantly increasing size, which would render extirpation necessary. The third case is another one of the same type. The tumor was on the left side. That patient is alive after nearly four years, and the exact nature of his condition is a question; but I believe it belongs to this class of mediastinal dermoid. Among other mediastinal growths, referred to by Dr. Matas, I should like to call attention to a case of lymphosarcoma with exceedingly rapid growth in a child, 9 years of age. I believe it belongs to the group of cases which Dr. Matas has discussed so brilliantly, with regard to whether or not temporary relief can be secured. This patient was under observation for six weeks before death. No procedure was of any avail. In the more benign types of tumor, such as Hodgkin's disease, radium or roentgen ray can be used as a diagnostic measure, by reason of the therapeutic effect, while, on the other hand, true infiltrating malignant growths which extend out along the paths of least resistance show little if any response to roentgen-ray or radium therapy. Although it is true there is some temporary relief, that is about all that can be expected in this type of malignant growth of the mediastinum. In regard to Dr. Fischer's paper, it so happens that I have under observation two cases of thoracic stomach, one in a child and one in a woman, 62 or 63 years of age. Both of these cases are exceedingly interesting in relation to the type of operation he has depicted, of drawing the stomach up into the chest. These two individuals are comfortable and well. The child had to have a palliative operation through the diaphragm for an obstructive lesion. I believe this type of stomach is developed above the diaphragm, while, in true hernia, the stomach is actually formed below the diaphragm and then passes up into the chest cavity. One other case of thoracic stomach has been reported in Chicago. The author states that, in his opinion, it is possible for the stomach to develop above the diaphragm. Shortly after seeing this child, we saw the case in the woman over 60, in whom the stomach was entirely behind the heart, the esophagus entering the stomach above the diaphragm. In a true hernia, the esophagus must come from below. If one makes a differential diagnosis between intrathoracic stomach and hernia, it is made by the way in which the esophagus enters the stomach. The point is that these two individuals are in robust health, one a young subject and one old, with their stomachs entirely in the chest cavity.

Dr. Franz J. Torek, New York City: I will confine my remarks to carcinoma of the esophagus. Dr. Fischer and many others have pointed out that

thus far the results of surgical treatment of carcinoma of the esophagus are not very encouraging. To improve the results, there are two factors necessary, one is the improvement and simplification of the technic and the other is the recognition of the cases at the time when they are still favorable for operation. Now, as for the first of these requirements, many of us in this Association have done our best to improve the technic and to simplify it. I am sure we have worked very, very hard. I cannot say that the general medical public has come up to the second requirement, namely, the recognition of carcinoma of the esophagus at a time when it is still operable. We operate on practically all patients that are sent to us, and it has been our unfortunate experience that many of the cases are so far advanced that the tumors either crumble under our hands or are adherent to the connective tissue around, having worked through the walls of the esophagus, instead of affecting only the mucous lining, to such a degree that often both pleurae are affected, and extirpation offers an enormous number of difficulties and is often unsuccessful. Dr. Lilienthal used a comparison which I thought was very apt, when he likened the condition to appendicitis, thirty-five years or more ago. No patient with appendicitis was ever operated on unless he presented a large mass, easily made out by dulness on percussion, consisting of a large abscess. At that time the voices that decried any operation on an appendix that was not perforated were very loud. At times, a surgeon who suggested operating on a nonperforating appendix was looked on almost as a criminal, and, at the present time, surgery of the esophagus is in almost the same antiquated state. If a patient is still able to nourish himself by swallowing soft food, and is not losing flesh, even the suggestion of performing a radical operation for carcinoma of the esophagus is looked on as criminal. It is my hope that we will advance in this branch of surgery in the same degree that we have advanced in the surgery of the appendix. The misfortune is that the diagnoses are not made early enough. The trouble is that the esophagoscope is not used early enough. If there is the slightest suspicion of trouble in the esophagus, an esophagoscopy is decidedly indicated. For example, if there is some obscure condition in the lower colon, we do not debate about performing a sigmoidoscopy, we consider it our duty to do so. We have not yet gone so far as that in the matter of carcinoma of the esophagus. Dr. Robinson, in his presidential address, made the remark that physicians will find a good deal of trouble in getting a surgeon to perform their thoracic work. I was somewhat astonished at first when I heard this; but I believe he is right. It is really true, and the reason is that the practitioner seeks the surgical advice of a person who has paid no attention to thoracic surgery and consequently will have different ideas from those which we are expressing here. If these physicians would apply to any one of this assemblage, he would find no difficulty in receiving surgical aid for his patient. This very apt remark of Dr. Robinson's has two sides, the other side being that we thoracic surgeons find a great deal of difficulty in getting physicians to send their patients to us. I am sure you have all had that experience, and, as I said before, our diagnosis should be made early. To give one instance in relation to this subject, take the symptom of the hysterical globus in the neck, in which there is difficulty in swallowing, called hysteria. If that symptom occurs in a young person, 16 or 20 years of age, all right, call it hysterical globus; but if this symptom occurs in a person, 35 or 50 years of age, the person who passes it off as an hysterical symptom is not doing his duty. It is his duty to have esophagoscopy employed and to find out whether the hys-

terical globus is not simply a distant symptom of a deep-seated lesion. If we find these deep-seated lesions earlier, at a time when only a portion of the mucosa, or muscularis, is involved, and the outside of the esophagus is still perfectly free, the likelihood of infection is small, the likelihood of bleeding is small, and our results will be a great deal better than they are at the present time. I believe that it is very fortunate, as far as the technic of the operation is concerned, that we are not all working along the same line, that we are working in different directions. By doing so, we can compare notes, and we should not—if we consider that perhaps one line of attack appeals to us as being something new and different—at once discard the older methods. They may be all right, and a great deal has been said of the extrapleural attack. At present, I admire it, and it may be the better one; but we do not know. We should not give up the transpleural method by any means. Some should work by the transpleural and others should work by the extrapleural method. Which of the two is going to have the final say, we cannot as yet determine. The main thing is that we inspire our medical friends to make early diagnosis and use the esophagoscope earlier.

Dr. Evarts A. Graham, St. Louis: In the first place, concerning the presentation of the subject of anterior mediastinal tumors by Dr. Matas, I was very much interested in his discussion and presentation of the question of decompression of these tumors by splitting the sternum longitudinally, because recently I have had an experience of a similar nature. A man had symptoms of dyspnea over a period of about three months, which seemed to begin with an attack of what was thought to be influenza. He was a traveling salesman and observed the first symptoms while on the road somewhere. He was brought to St. Louis and went to a different hospital from the one where I generally work. There a diagnosis of left-sided pleural effusion was made, and 3,000 c.c. of bloody fluid withdrawn, said to contain pure culture of the bacillus of Friedländer. Following this, a large shadow was revealed by the roentgen ray, which was thought to be an enlarged pericardium. The man's dyspnea was only partially relieved by withdrawal of the pleural effusion. Twelve different attempts were made to aspirate the pericardial cavity, all without success. I was asked to see the man in consultation. When I saw him, he was in most extreme orthopnea and cyanosis; his fingernails were almost black. He had been able to assume only a forward reclining position for two weeks. He sat up in bed, leaning forward over a small table, which was the only way he could live. On the basis of the shadow revealed by the roentgen ray, which showed an irregularity on the right side of the pericardium in addition to an enlargement of the axillary glands on both sides, which I think Ewing called attention to first, I made a diagnosis of probable mediastinal tumor. The man was very evidently near death from dyspnea. I advised immediate decompression of the anterior mediastinum for the purpose of exploration, hoping that decompression might give some respiratory relief. He was accordingly taken to the operating room, and, under local anesthesia, we split the sternum longitudinally from top to bottom, using a chisel part of the time and part of the time a rongeur. To our suprise, there was no particular gaping after splitting the sternum. The operation was performed under the most extreme difficulties; it was like lying on one's back in the street to repair an automobile from below. The patient had to lean forward during the entire operation. We combined, with the operative procedure, inhalations of oxygen. After splitting the sternum, the dyspnea was not materially relieved; but I found a huge mediastinal tumor which I diagnosed

as probably a lymphosarcoma. The patient died one-half hour after operation. Only a limited necropsy was permitted; but we found a lymphosarcoma which completely surrounded the trachea and enlarged bronchi and also encased the heart. This represents another case of the type of tumor which Dr. Matas mentions, from which we cannot expect decompression to afford very much relief—a constricting tumor, one which not merely causes pressure. I believe that the immediate cause of death was a failure in oxygen. It seemed so to us at the time. There was no proper equipment for intratracheal or intrapharyngeal administration of oxygen. We tried to give oxygen through an ordinary nitrous oxid machine, but it was unsatisfactory. The oxygen supply finally gave out. I believe if these things had been taken care of before, the patient's life might have been spared, at least as long as that of Dr. Matas' patient. One thing I wish to speak about is the question of thoracic stomach, which Dr. LeWald brought up. About a year ago, in the St. Louis Children's Hospital, a patient, 5 years of age, was brought to Dr. Clopton, with a discharging sinus from the left chest and a history of pneumonia about six weeks previously. He had been operated on for empyema by his local physician and had been left with a discharging sinus. We found, however, that this sinus was not a pleural sinus, but extended into the stomach, which was in the pleural cavity. The question arose whether the child ever had empyema, or whether, during the operation for empyema, the diaphragm had been injured, resulting in a diaphragmatic hernia. This aroused some interest on our part, and we found two other cases in the literature in which apparently a diaphragmatic hernia of the stomach had been operated on, under the supposed diagnosis of empyema. It is not an unnatural diagnosis to make without a roentgen-ray examination. If a patient with a thoracic stomach happens to have pneumonia, a needle is put in and material obtained which looks a little like pus; it is not at all surprising that a diagnosis of empyema should be made in such a case. The interesting thing in the case I mentioned is that the child was treated conservatively in order to clear up a considerable amount of infection which came from burrowing of the infection beneath the skin, so that there were two or three sinuses, instead of the original one. The sinus closed spontaneously. The child gained rapidly in weight, and he has now no symptoms whatever from the thorax. No attempt has been made to repair the supposed diaphragmatic hernia, and the child is without symptoms. One other point concerns the handling of carcinomas of the esophagus, particularly by the method suggested by Dr. Lilienthal. If the principal danger in this procedure, and in procedures on the esophagus, is infection of the mediastinum, then, of course, any method which eliminates infection would supposedly be one of the best. Dr. Lilienthal, I believe, in his two-stage method advocates the use of a cuff of skin. That is a very ingenious device; but, nevertheless, the skin always contains bacteria, therefore, there is always danger of introducing bacteria into a denuded mediastinum by such a procedure. For this reason, I would call attention to some experimental work on dogs done in our laboratory by Dr. Allen (*Ann. Surg.* **76**:157 [Aug.] 1922). Although it has not been applied to human beings, and, therefore, may not be so satisfactory as in dogs, nevertheless, it gives promise of offering a satisfactory method. The method consisted in using a double flap of fascia lata around the esophagus. The first stage consisted of isolation of the esophagus and the placing of a double cuff around the portion to be excised. Two weeks later, the portion of the esophagus to be excised, with the inner layer of fascia lata, could be readily removed. The outer layer of fascia lata had become

vascular, could be promptly sutured over, and, in practically every instance in a series of thirty-one dogs, survival took place, without any evidence of infection. The fascia lata forming the cuff later becomes lined with epithelium, by both upgrowth and downgrowth, and, though there is some tendency to stricture formation, in dogs at least it seems to do away with the danger of infection of the mediastinum.

DR. KARL SCHLAEPFER, Baltimore: I had the opportunity, a year ago, of seeing Dr. Lilienthal's case in New York. I was much impressed by his method. In regard to his operation, I wish to make two suggestions which I failed to find in different articles dealing with this new operative procedure, which seems to me to offer a very bright outlook in thoracic surgery. One is preliminary gastrostomy, or, if the surgeon intends to use the stomach for his plastic work, perhaps jejunostomy. I had a wide experience with jejunostomy during my stay in Vienna with Professor von Eiselsberg. By using jejunostomy as a preliminary procedure, we have the whole stomach at our disposition for further plastic operation within the thoracic cavity. By performing a gastrostomy, or jejunostomy, we avoid mechanical irritation of the tumor. In about ten necropsies in cases of cancer of the esophagus, I was impressed particularly by the fact that the growth is partly due to inflammatory reaction. This reaction makes it difficult for the surgeon to decide whether the case is suitable for radical operation or not. By performing a preliminary gastrostomy, we can avoid the passage of any food through the esophagus, and we can reduce the size of the tumor by avoiding any further mechanical irritation of the growth which will lessen the inflammatory reaction around the tumor. I might compare this procedure with a similar one used in cancer of the rectum, where, by means of a preliminary colostomy, we see the growth diminish in a short time. A very helpful therapeutic procedure would be the combined use of radium, in the form of needles introduced into the tumor, and the roentgen rays for destroying tumor cells in the neighborhood of the growth and in the regional lymphatics. By using this procedure, we might find, after a short time, a well circumscribed tumor, the pleura perhaps thickened, and, in this way, the patient well prepared for the second operation as suggested by Dr. Lilienthal. These two procedures, it seems to me, would open a new prospect.

DR. ROBERT T. MILLER, Baltimore: At the risk perhaps of boring the members of this association, I should like to speak of some experimental work in which we have attempted to devise a method of esophageal resection and suture. Through the courtesy of Dr. Halsted, this work was carried out in the Hunterian Laboratory of the Johns Hopkins Medical School during the fall and winter of 1921-1922. In a general way, the plan adopted was to free the diaphragm from the stomach at the cardia, to draw the stomach into the left pleural cavity, to resect a portion of it in its lower third, invaginating the cardiac end of the stomach and implanting the end of the divided esophagus in the wall of the fundus of the stomach. The method of suture used was, in principle, the "blind-end" method reported by Dr. Halsted (*Ann. Surg.* **75**:356 [March] 1922), though the technic he described was altered in certain details. The result of suture by this method was rather surprising, since, contrary to the experience rather generally reported heretofore, the suture in our work did not tear out. This method of anastomosis resulted in an opening which functioned. The series represents hardly twenty dogs as yet, and perhaps four dogs have died after operation; but, when the animal survived, the operation resulted in a functioning anastomosis. We, therefore, believe that esophageal suture can be carried

out in the pleural cavity of a dog with a rather certain degree of success. In 1920, Kirschner, in the *Archiv für klinische Chirurgie* made a proposal to adopt the same scheme, though in a rather more elaborate fashion. His proposal was to divide all the blood vessels going to the stomach, except those coming in from the right end. A stomach so mobilized could then easily be drawn to practically the superior limit of the pleural cavity. Before we found this article, we had started with just this idea, knowing nothing about his work. It is surprising how much of the stomach one can draw up into the chest. If one adopts the proposal of Kirschner with reference to the division of blood vessels, it is perfectly possible to dislocate the entire stomach of the dog into the chest, suturing the diaphragm to the pylorus. However, we found in dogs that so extensive a division of the arteries supplying the stomach would not be tolerated. A division of the coronary, vasa brevia and left gastro-epiploic arteries results, within four or five days, in a perforating ulcer of the stomach wall in more than 75 per cent. of the cases. This condemns the method. Division of the coronary and vasa brevia arteries alone appears to leave a perfectly viable stomach. If one divides the two arteries mentioned, it is possible to dislocate the stomach far enough into the chest to replace practically the entire thoracic esophagus. In the dog, then, we have a successful method of suture and a feasible method of mobilizing the stomach. It remains to be seen whether one can replace the entire thoracic esophagus in this way, and experiments are now being carried on with this object in view. Is this method applicable to man? Unfortunately, we cannot tell, since we have had no opportunity to apply it. The possibility of suture of the human esophagus has been doubted because of the supposed absence of a submucous layer in its wall. We believe this is not true, and offer as evidence the fact that we have found a double suture line of silk, placed in an esophagus freshly removed from the human cadaver, able to withstand a pressure of about 6 feet of water before there is leakage of either air or fluid. Such security is well beyond any clinical demand. Secondly, we have found that, by stripping the mucosa from the lower part of the human esophagus, a layer of submucosa can be demonstrated strong enough to break a fine intestinal suture needle. By analogy, then, one might reasonably infer that the human esophagus will lend itself to suture. If it is possible to develop a technic for resection of the esophagus and restoration of that tract by this method, we will have made perhaps a start toward converting the present hazardous and unsatisfactory operative treatment of esophageal carcinoma into a procedure analogous to intestinal suture and possibly approximating it in simplicity. The result of attempts to restore the destroyed esophagus by constructing an antethoracic canal have been of doubtful value, inasmuch as but one case has been reported as completed within three months, and most of them have required from six and a half to nine months, the prolonged struggle with the resulting fistulas having been completed usually hardly before recurrence has made itself evident. I hesitate to present so brief a summary of this work, and, especially, since we have as yet not been able to attempt it in man. So far as experimental evidence goes, Dr. Andrus and myself feel greatly encouraged in the belief that ultimately the operation will be shown to be feasible.

Dr. John L. Yates, Milwaukee: I had the privilege, during the last week, of seeing Dr. Miller's work, and I became convinced that he is finding the solution of the problem of excising the lower end of the esophagus, if not the middle portion as well. Like Dr. Matas and Dr. Graham, I have attempted mediastinal decompression. My result was thirteen times inferior to that of

Dr. Matas since the patient lived for twelve hours. Usually, if there is indication for mediastinal decompression, there is advanced periadenitis with adhesions, and these conditions make decompression impossible. On the other hand, patients so affected can be carried along for months, with far less distress, under proper dosage of roentgen ray. Dr. Whittemore is to be congratulated on the excellent work he is doing. He brought out a point of clinical significance when he spoke of "liver-like" consistency in the lung above the tumor. We were forced to the conclusion that after gunshot wounds such carnified lung is a menace in the chest and will never function again. If this is true, immediate resection of carnified lung is indicated, even if resection amounts to lobectomy. There was an old superstition that sunlight and scar tissue were the chief factors in controlling tuberculosis. It is now recognized that the most important element is local resistance, the result of which is the formation of scar tissue. In combating disease, this local resistance is of the utmost importance and depends directly on an adequate blood supply. Physiologically, it is desirable not to cause the formation of scar tissue which reduces the blood supply, but to increase the blood supply with the subsequent formation of scar tissue, if such is necessary. Thus it is that phrenotomy, which causes true diaphragmatic paralysis, leads to a maximum blood supply, and hence to the provision of the best opportunity for spontaneous healing.

Dr. Carl A. Hedblom, Rochester, Minn.: We had one case at the Mayo Clinic in which I split the sternum longitudinally. There was considerable spreading of the cut edges, but the symptoms were not appreciably relieved. The patient lived for a few days after operation. The mediastinal tumor proved to be lymphosarcoma. I was much interested in Dr. Whittemore's case report. Recently, we have had two cases of dermoid of the thorax. One was not diagnosed, but was found at necropsy. The patient came to the clinic, presenting a typical picture of exophthalmic goiter. While receiving preliminary treatment for this disease, she developed symptoms of pleural effusion. Aspiration yielded a canary yellow fluid which was sterile; but a culture from a specimen obtained later showed pneumococci. Hypochlorite irrigation failed to diminish the size of the cavity or to sterilize it. In the meantime, a double ligation was performed, the crisis occurred, and the patient died of hyperthyroidism. Necropsy revealed a dermoid of the diaphragm, with two balls of hair in the pleural cavity. The second case was that of a man who first came to the clinic several years ago with symptoms of pulmonary abscess. He refused operation, and a spontaneous perforation occurred on the anterior chest wall. At operation last winter, a dermoid of the pericardium was found, with surrounding abscess cavity which had perforated into a bronchus. The dermoid tumor was covered with a sparse growth of short hairs, and there were masses of hair free in the abscess cavity, which was lined with squamous epithelium. The dermoid was removed, and the cavity walls and bronchial fistula were cauterized. The patient made a good recovery. Regarding the retropleural approach to the esophagus, those familiar with the literature will recall that the operation has been repeatedly described, and it has also been performed on the living patient. The relative merits of a right-sided and a left-sided route have also been discussed, with advocates for each. I have tried both, and, from my limited experience, I favor the right-sided approach. Here the aorta is not in the way, and in the region of the middle portion of the esophagus, the arch of the azygos veins acts as a guide to the esophagus. After this vessel has been doubly ligated and cut,

an unobstructed access is afforded to the region of the esophagus, which is inaccessible from the left side, owing to the arching of the aorta over it. Unfortunately, the cases I have had have been inoperable in the sense that the tumor had infiltrated the tissues surrounding the esophagus. In one such case, I tore the esophagus in liberating the tumor. The patient died on the sixth day, of mediastinitis. A second patient lived twenty days and died of leakage, caused by cutting through of the sutures in the lower stump. During the resection, I encountered a milky fluid which I thought was pus. I, therefore, did not use so much precaution in suturing the stump as I otherwise would have done. Later, I discovered that this fluid was not pus, but chyle from a tear in the thoracic duct. I believe that failures in the past in operating for carcinoma of the esophagus have been due in part to technical difficulties which can be overcome partly at least; but we must operate before the disease has infiltrated the surrounding structures.

Dr. Nathan W. Green, New York City: Regarding carcinoma of the esophagus I should like to relate a personal experience. Last winter I was called to one of the principal hospitals in New York by one of our medical men and by one of our surgeons to examine, with the esophagoscope, two cases of esophageal obstruction. I made the diagnosis of cardiospasm in one case, and this the medical man retained. In the other, I made a diagnosis of carcinoma, and, on this diagnosis, the surgeon operated. He used Dr. Torek's approach and stripped off the pleura of the left side from the mediastinum, thereby obtaining a good exposure of the carcinoma. However, to make a long story short, the pleura that was stripped off sloughed, and the patient developed a septic pleuritis on that side and died on the ninth day. The reason for mentioning the case is this: He said, "What shall we do?" It seemed to me that if one could establish an aseptic inflammation in the pleura, so that the visceral pleura might be glued tightly to the parietal pleura before operation, a considerable amount of inflammation in the mediastinum would not then be so disastrous, as there would be no free pleural cavity to contaminate. I suggested to him that if he should operate in another case he should inject "aleuronat" into the pleural cavity, in this way attempting to obliterate the pleural space by a sterile chemical inflammation.

Dr. Willy Meyer, New York City: I am sure that every one of us has the feeling that this discussion has been not only impressive, but extremely stimulating. There is still a kind of "lull" in esophageal surgery, principally because the roentgen ray and radium have appeared as factors in the treatment of esophageal carcinoma, and rightly so, perhaps. About three years ago, the late Dr. Henry H. Janeway of New York told us, at one of the meetings of the New York Society for Thoracic Surgery, that he had had under his care for radium treatment as many as thirty-five cases of esophageal carcinoma at the Memorial Hospital. That was in but one hospital! It is thus easy to see why surgeons at present have comparatively little chance to operate for carcinoma of the esophagus. The principal reason for the lack of confidence in surgery on the part of the medical man seems to be that surgeons cannot yet present to the general practitioner "a series" of patients with carcinoma of the esophagus treated and cured by operation. Dr. Meltzer once said, "Give the surgeons at least the chance to do the operation, then they will gradually develop the various methods." As has been frequently stated, we all have to continue to work for the early diagnosis of esophageal carcinoma. I fully concur with Dr. Torek's view, namely, "that we ought to work transpleurally as well as by the mediastinal approach in operations for

cancer of the esophagus." Surgeons approach the kidney from the front and from the back. Let us always remember that we are at the very beginning of this chapter of surgery, and that, therefore, it will take some time before we shall be able to determine what is best in the various methods. The transpleural approach certainly gives wonderful access; one can see and find out from the start whether or not the case is still operable. In one instance, the local condition at the seat of the esophageal tumor seemed to me to permit of radical removal, yet we found metastatic deposits in the lung. This, of course, could never have been detected when approaching the esophagus by the posterior mediastinal route. The success in the transpleural resection is, it seems to me, principally a question of correct airtight drainage. Moved by the pitiful appeal so commonly made by these patients with malignant esophageal stricture to give them back the ability to swallow, I was led, in two instances of inoperable carcinoma, to divide the esophagus above the stricture, inverting the distal stump and transposing the proximal portion extrathoracically. Both patients stood the operation well and lived for from seven to eight days. One of them died of pneumonia; in the other, the necropsy proved that, with typical airtight drainage employed in the after-treatment, the lower portion of the lung had become adherent to the chest wall, while, within the upper part of the pleural cavity, there was some accumulation of fluid, septic material, which took the life of the patient. I only mention these cases because we learned from them that it is the "proper drainage of the chest" which seems to decide the patient's fate. Again let me emphasize that we are at the beginning of this chapter of surgery. I, therefore, believe that the transpleural, as well as the posterior mediastinal, approach should be further tried in this class of cases. Gradually, we shall learn when one is indicated and when the other. But we certainly should not hesitate, but continue to report our experience for the benefit of all interested, even if we did not succeed in saving the patient's life. We should state in the literature what operation and observation of the case during the after-treatment have taught us. After all, it seems to me, that at this very moment the final effect of radium and roentgen-ray treatment is a question of paramount importance. There are a few cases on record in which, it is claimed, radium caused an esophageal carcinoma to disappear, and the patients are alive today. On the other hand, we have Dr. Torek's patient alive today, eight years after operation. We have, in his case, the clear proof that a patient operated on at a comparatively early stage can recover from the operation and remain cured. Therefore, I say, what is important at the present moment is a response from the men who treat these patients with radium and the roentgen ray, stating what they have accomplished up to date. Then we can compare notes. It certainly is a real pleasure to hear how members of our Association are pushing ahead, and, in spite of roentgen ray and radium treatment, are working at the resection of esophageal cancer. I had a case of tumor of the mediastinum which, to me, was extremely interesting. The patient was operated on three years ago, when the American College of Surgeons met in New York. The anesthetist had great difficulty in introducing the catheter for intratracheal insufflation. Bloody mucous oozed out of the catheter before operation was begun. We found a large cystic tumor directly above the diaphragm, which proved to be a cold abscess from a tuberculous mediastinal lymphatic gland. The patient died, with the temperature rising to 107 F. on the second day after the operation. Necropsy demonstrated that death was due to a most acute pneumonia. During the discussion here today,

the topic of diaphragmatic hernia was touched on. Lately, we had a baby boy, aged 16 months, at the hospital, with a congenital diaphragmatic hernia. He had entered with the diagnosis of pneumonia; but, on observation, it became evident that we had to deal with a typical intestinal obstruction, and that a large portion of the intestinal tract was within the right chest. Purgatives had brought no response. Although we were almost sure from the clinical and roentgen-ray examination that we had to deal with a congenital diaphragmatic hernia, we decided, after careful deliberation, to open the abdomen first, in order to determine the correctness of the diagnosis. When I first saw the little boy, he had been in the hospital for three days. At first, there had been vomiting; but, during the last twenty-four hours, this had ceased. We opened the abdomen and found pus. At the lesser omentum we saw pus shining through. A very large liver filled out the dome of the diaphragm completely; a hernial aperture was not visible. In the depth, we found a part of the transverse colon, like a small band, but we could not move it. The coils of the jejunum and ileum were partially in complete collapse. While following the small intestine from the upper jejunum downward in order to find the cause of an obstruction in its course, the child vomited and died from suffocation, the result of fecal drowning. All our efforts at resuscitation proved of no avail. We continued searching and found a large hole in the diaphragm to the outer side of the upper pole of the right kidney. Having meanwhile obtained permission for a wound inspection, we enlarged the diaphragmatic hernial aperture and withdrew from the chest the lower ileum, the ascending, and part of the transverse colon. In the middle of the latter, there was a gangrenous area which had perforated. The lung was completely compressed and atelectatic, close to the spine. I learned important lessons from the case, which I shall never forget. First, in the future, I shall, even in babies and in the absence of vomiting, wash the stomach before operation, if there is the slightest suspicion of an intestinal obstruction. Secondly, in the case of a suspected diaphragmatic hernia, I shall enter the thorax first. Had I done this in the present case, we should have been able to make a definite pathologic diagnosis "during the life of the patient," and, if the purulent infection present had proved not to be of too severe character, I believe there would even have been a chance to help the little patient by the operation after the thoracotomy, in spite of the gangrene of the colon. The case shows that such patients can, for a time, be perfectly well, with functioning of the small and large intestine, although one lung is completely compressed. The question is, Should they be operated on? I believe they should, if they can be taken in time.

Dr. Rudolph Matas, New Orleans: Anterior median thoracotomy by complete longitudinal division of the sternum for thoracic decompression was performed in a case of mediastinal lymphosarcoma, characterized by progressive asphyxial phenomena. A decompression operation, performed for purely palliative purposes, thirty-six days after a preliminary tracheotomy, with permanent intubation down to the bifurcation, had failed to relieve the patient's increasing distress. Temporary relief was obtained during the operation, followed by cardiorespiratory exhaustion and death, four hours after the intervention. The clinical observation, with necropsy findings and commentaries on the value of midsternal decompressive thoracotomy as a palliative measure in inoperable mediastinal tumors, will appear in the original paper to be published later as a separate contribution to the transactions. This discussion has, at least, brought out three unpublished cases. They all con-

firm the impressions gathered from the literature and from my personal experience. The idea of decompression as applied to intrathoracic neoplasms has no analogy in the principle of decompression for the relief of intracranial tension. This is particularly true of the malignant growths of the mediastinum, which not only compress, but penetrate, infiltrate and block the respiratory passages. All such cases have proved fatal in spite of sternotomy. The three new cases of complete longitudinal median sternotomy, so interestingly reported by Drs. Graham, Yates and Hedblom, all point to the same conclusion, namely, the benefits that may accrue to the patient from median sternotomy for decompression in inoperable intrathoracic growths are, at best, only palliative and so ephemeral in duration that they scarcely justify the operative risk and hardship imposed on these hopeless patients. Greater relief can be obtained by the free administration of morphin and other succedanea. If only in this negative sense, I believe some good has come of this discussion.

Dr. Hermann Fischer, New York City: This subject is so extensive that it is difficult to summarize it in three minutes. I should like to say, however, a few words about the impressions that I have gained from my studies of the subject. In our hospital, it was only natural to follow Dr. Torek's technic on account of the very beautiful result he has achieved by it, and we still believe that the transpleural route as far as exposure is concerned is the method of choice. Kümmel, in Germany, Dr. Lilienthal of New York, and others who look upon the transpleural approach as too dangerous and producing too much shock, have now turned to the extrapleural method. Of course, we are still only at the beginning, and we do not know how successful we shall be with this method in the future. It seems to me that in these extrapleural operations we often start extrapleurally and end with an intrapleural operation. It seems that all have not been so fortunate as Dr. Lilienthal in avoiding opening of the pleural cavity. If the pleural cavity is once opened, we expose it to the same dangers as in the transpleural method, but at the expense of room. I grant that the transpleural approach is more formidable. The reflexes from a widely opened pleura are surely not indifferent. The majority of patients are emaciated by the ravages of the disease, and the shock of the operation is consequently great. I have no personal experience with the extrapleural approach, and, although I have seen from the pictures Dr. Lilienthal showed this morning that the approach seems adequate, I believe I shall continue to use the transpleural method. In my own work, I have had the misfortune of always receiving far advanced cases, in which the seat of disease was mostly near the bifurcation. In all cases, I succeeded in removing the tumor, but all patients died from shock. I believe the best results will be achieved if the whole esophagus is removed from the thorax, because all endeavors to make a tight suture in the human being have been fatal. How far the method Dr. Miller has suggested will be successful remains to be seen.

Dr. Howard Lilienthal, New York City: The skin flap is not necessary. The operation may be performed without any skin flap, according to Dr. Neuhof, who resected the esophagus in the neck in dogs. Epithelization occurred over the raw surface of the area left by the resection, and the dogs were able to swallow. In man, I believe an esophagus thus resected would probably close up by stricture, though sounding might keep the passage open. An operation for resecting cancer of the esophagus should not be performed if thorough radium treatment has been previously employed, because of fibrous adhesions to the surrounding organs. We have had cases of this kind—hope-

less after radium because of the presence of this tough periesophageal fibrous tissue. In cancers of the esophagus in which the patients cough, we must perform bronchoscopy as well as esophagoscopy. One of my patients died, in whom an endobronchial carcinoma existed unrecognized until necropsy. We must operate on sick dogs and healthy men if we are to come to a proper understanding of the relative advantages of surgical procedures. Surgery on healthy dogs cannot predict results of similar procedures in starved and emaciated human beings. In discussing Dr. Matas' paper, I should like to mention two instances in which I have performed longitudinal transsternal mediastinotomy. In one other, I attempted it, but without completing the operation. In the attempted case, the man was dying, and, on account of obstruction to the circulation in the large veins, there was tremendous congestion and so much bleeding that I had to desist. One successful case was that of a retrosternal goiter (Lilienthal, Howard: *Surg., Gynec. & Obst.* **20**:589 [May] 1915). Another case was like the case of Dr. Matas. I performed the operation with chisel and gouge. It is absolutely necessary to divide the posterior periosteum of the sternum, and then from 1½ to 2 inches of separation of the sternal halves will be possible. In cases of lymphosarcoma, the tumors nearly always surround the trachea, very probably because they start in the vestiges of the thymus. In my next case, I intend to cut down to the trachea through the tumor. I believe this can be done with relief of respiratory embarrassment. In my case of tumor (angiosarcoma), the patient lived for twenty-four days after operation and died following severe reactions from injections of Coley's toxins.

THE DIFFERENTIAL DIAGNOSIS BETWEEN TUBERCULOSIS AND LUNG ABSCESS

A CLINICAL AND ROENTGENOLOGIC STUDY OF TWELVE CASES SEEN AT ST. LUKE'S HOSPITAL *

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This brief paper is presented to record our recent experience in this class of cases and to promote discussion of this topic. Twelve cases form the basis of this report. Eight patients were operated on and the diagnosis established; all of these recovered. Four were not operated on for lung abscess, and, of these, three recovered and one died. None of these cases is included in a previous report of ten cases by one of us (N. W. G.).[1]

Following the classic and recent work of Dr. Lilienthal[2] and Dr. Aschner[3] on suppurative infections of the lung, we have employed the following classification: (1) bronchiectasis; (2) bronchiectatic abscess; (3) suppurative pneumonitis; (4) extrabronchial abscess.

As no resections of tissue were made in this series, we are able to say only that we had to deal with a suppurative cavity, in almost all instances, discharging pus through a bronchus.

It is probable that extrabronchial abscesses do not long persist as such, but sooner or later become connected with a bronchus, so putting themselves into Group 2 of the foregoing classification. Then they become bronchially discharging abscesses. In Cases 11 and 12, this probably occurred very early. Both of these showed large single abscesses, with fetid and copious expectoration.

The history of these cases has been either postpneumonic or postoperative. Two cases followed a tonsillectomy. One case followed an operation on the gallbladder. In none of this series was a foreign body demonstrated as the cause.

The outstanding symptom in these cases was a persistent cough with profuse sputum with a fetid odor, accompanied by a loss of weight. The sputum in two cases did not have the fetid odor. Two cases had

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* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

1 Green, N. W.: Lung Abscess, Ann. Surg. **70**:539 (Nov.) 1919.

2. Lilienthal, Howard: Resection of the Lung for Suppurative Infections, Ann. Surg. **75**:257 (March) 1922.

3. Aschner, P. W.: The Pathology of Lung Suppuration, Ann. Surg. **75**: 321 (March) 1922.

been of approximately two years' duration and one had lasted but twenty-one days. The last patient was not operated on and died, overcome by the general infection.

Eight cases, on examination of the sputum, showed no tubercle bacilli, and, in addition, one case gave a negative Pirquet reaction. Two patients did not have the sputum examined while at St. Luke's Hospital; but the sputum had been previously examined for tubercle bacilli by the department of health, New York, with negative results. One patient who died was acutely ill all the time and had no record of examination for tubercle bacilli. In his case there was a massive

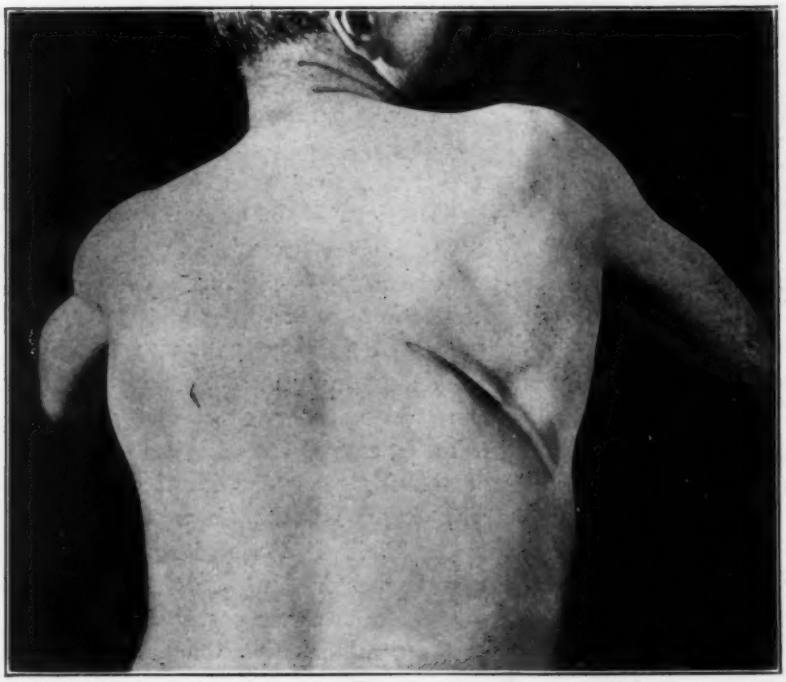

Fig. 1 (Case 8).—Abscess of the right lung that was regarded as a case of pulmonary tuberculosis for a number of years, the patient being treated at a tuberculosis sanatorium. Roentgen-ray examination revealed the true nature of the condition (Fig. 2). Operation by the two-stage method resulted in complete cure (Fig. 3).

necrosis of nearly the entire upper lobe. No tuberculosis was present in any of these twelve cases. In three cases, pneumococcus Group IV was found.

Of the patients that were not operated on for lung abscess, one was discharged from the hospital improved; one was cured, and one

died. One came under observation, but was not admitted to the hospital and was cured two months after the onset. Of the patients operated on, five were improved, and three were reported cured.

Four patients had one operation, and four had two operations. Three of the latter were two-stage operations. The first stage consisted in packing down to the pleura, and the second stage in opening

Fig. 2 (Case 8).—Circumscribed cavity with fluid level and no evidence of tuberculosis.

the abscess cavity. Twice the lung was opened with the cautery. In one case the abscess discharged into the lung after packing with gauze. One patient in whom the abscess had been drained, and who had an overlying empyema, improved, and later required a resection of two or three ribs to obliterate the residual empyema cavity.

DIAGNOSIS

The differential diagnosis lies in the history of the onset, the character of the sputum and the absence of tubercle bacilli (one patient spent six months in a tuberculosis sanatorium, but tubercle bacilli were never found in the sputum). Two other patients had been previously referred to the tuberculosis service of the department of health, city of New

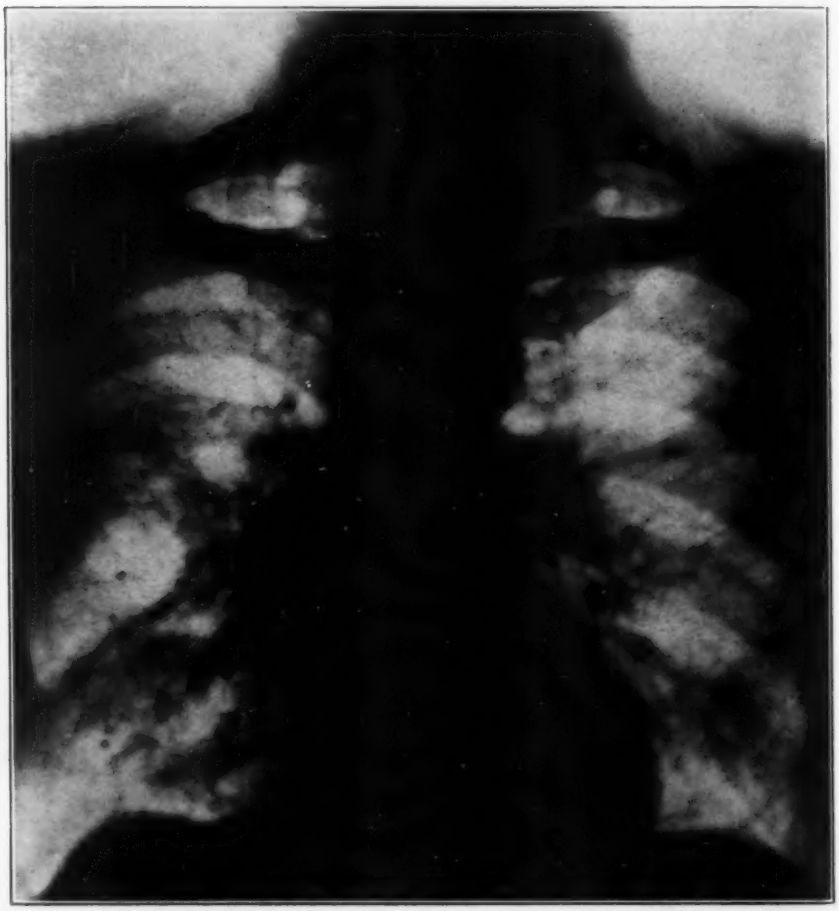

Fig. 3 (Case 8).—Disappearance of all evidence of abscess cavity, seven months after operation.

York, where, on roentgenographic examination, the diagnosis was corrected. Clubbing of the fingers, to a greater or less degree, is one of the frequent physical signs. If correctly interpreted, the roentgenographic examination is the most reliable means at our disposal in differentiating the pathologic condition of the lung.

REPORT OF CASES

CASE 1.—W., woman (patient of Dr. Martin), was admitted, Oct. 30, 1916. No tubercle bacilli were found in the sputum. A one-stage thoracotomy was performed, Jan. 15, 1917. The patient was discharged improved. She gave a history of onset of symptoms, four months before the operation, following pneumonia. The temperature on admission was 100.2 F.; the white blood count, 20,000.

CASE 2.—L., man (patient of Dr. Vogel), was admitted, May 20, 1919. No tubercle bacilli were found in the sputum. He was discharged three months after inception of symptoms, without operation, and improved. The onset of symptoms occurred eight weeks after pneumonia, with cough, spitting of blood and pain in the right chest. The temperature on admission was 100 F.; the leukocyte count was 11,000.

Fig. 4 (Case 9).—Abscess of the upper lobe of the right lung, following laparotomy for gallbladder disease, three months previously. The patient had presented himself at the clinic of the health department, where a roentgen-ray examination disclosed abscess of the lung (Fig. 5) and led to operative treatment and cure (Fig. 6).

CASE 3.—O'R., woman (patient of Dr. Patterson), was admitted, April 22, 1920. No tubercle bacilli and no elastic tissue were found in the sputum. Group IV pneumococcus was present. This patient was discharged, two years after the inception of symptoms, cured. She had been operated on one year and two months previously for empyema following pneumonia. One year later, after catching cold and spitting blood tinged sputum, the patient was readmitted. The temperature on admission was 104 F. The white blood count was 30,000. This case followed pneumonia.

CASE 4.—C., woman (patient of Dr. Mathews), was admitted, April 17, 1920. The onset of symptoms occurred fourteen days after tonsillectomy. No tubercle bacilli were found in the sputum. A one-stage thoracotomy was performed. The patient was discharged four months after the beginning of symptoms, cured. The temperature on admission was 100.4 F.

CASE 5.—McI., woman (patient of Dr. Green), came under observation, May 11, 1920. She gave a history of onset occurring six days after tonsillec-

Fig. 5 (Case 9).—Cavity formation with a definite fluid level in the right upper lobe; no evidence of tuberculosis; patient tilted to right side.

tomy. A roentgenogram by Dr. Wessler revealed a lung abscess, 1 inch (2.5 cm.) in diameter, in the right upper lobe, and another roentgenogram, taken two months later, after the patient had first come under observation, was interpreted by Dr. LeWald as revealing the abscess cured, with some thickening. The patient was discharged, cured.

CASE 6.—S., man (patient of Dr. Green), was admitted, Dec. 2, 1920, presenting Group IV pneumococcus. Inoculations of a guinea-pig produced no reaction. One operation, consisting of drainage of the empyema cavity and lung abscess, was performed, and later another operation, consisting of resection of two or three ribs to close the empyema cavity, was performed. The patient was discharged, one year and six months after the onset, improved. This case followed influenza. The temperature on admission was 103.6 F. The leukocytes numbered 63,000.

Fig. 6 (Case 9).—The cavity had entirely healed, three months after operation.

CASE 7.—C., woman (patient of Dr. Mathews), was admitted, Oct. 31, 1921. Examination was negative for tubercle bacilli, but positive for Group IV pneumococcus. A one-stage operation with drainage was performed seven weeks after a radical breast operation on the right side. The patient was discharged, two months after thoracotomy, improved. Feb. 9, 1922, the patient was cured. This case followed pneumonia. The temperature on admission was 100.6 F. The leukocytes numbered 17,800.

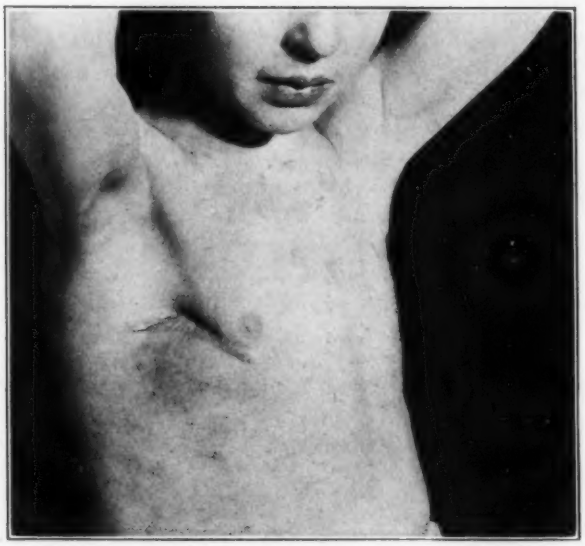

Fig. 7 (Case 10).—Abscess of right lung, of two years' duration, the origin of which is unknown. At the clinic of the health department, roentgen-ray examination disclosed abscess of the lung (Fig. 8), leading to operation and cure (Fig. 9).

Fig. 8 (Case 10).—Abscess of upper lobe of right lung, showing enormous size of cavity, and fluid level; patient tilted to left side.

CASE 8.—F., man (patient of Dr. Green), was admitted in December, 1921. There was no known cause for the abscess. The patient had coughed blood previously. The sputum was negative for tubercle bacilli. A two-stage operation was performed for drainage. In the second operation, the lung was opened by the cautery. The patient had acute symptoms, nine months before admission. Seventeen years previously, however, he was in a tuber-

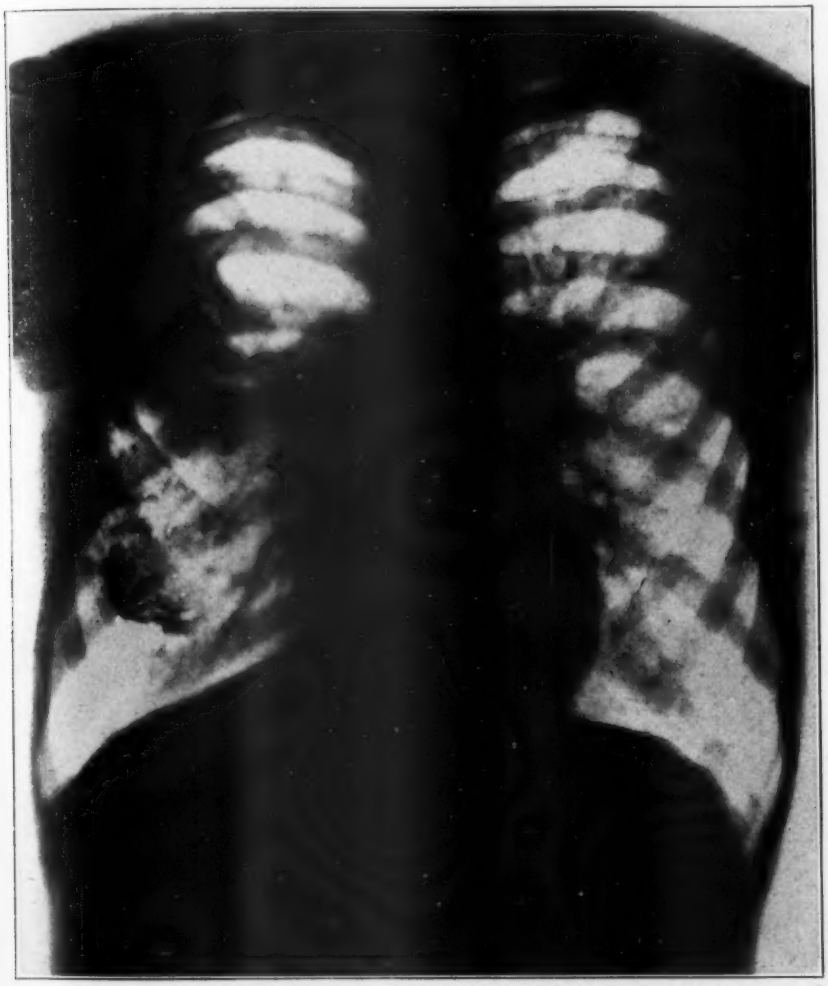

Fig. 9 (Case 10).—Complete drainage of cavity, two months after operation.

culosis sanatorium, but tubercle bacilli were never found in the sputum. This patient had gained about 30 pounds (13.6 kg.) in weight, and considers himself cured (Figs. 1, 2 and 3).

CASE 9.—L., man (patient of Dr. Green), was admitted, Jan. 1, 1922, with a history of symptoms lasting for three months before admission and following a laparotomy for gallbladder disease. The sputum was negative for tubercle

bacilli when examined by the department of health, New York. Operation was performed in two stages for drainage. The lung was opened with the cautery. The patient has gained about 25 pounds (11.3 kg.), and is cured (Figs. 4, 5 and 6).

CASE 10.—D., man (patient of Dr. Green), was admitted in January, 1922. The Pirquet reaction was negative. The sputum was negative for tubercle bacilli when examined by the department of health, New York. Symptoms were severe cough, which had lasted for two years previous to admission.

Fig. 10 (Case 11).—Abscess of lung following pneumonia, showing enormous cavity involving the left upper lobe, with two distinct fluid levels, owing to the difference in density of the material in the cavity. This closely resembles the test usually made of the sputum when it separates into two or three layers in a glass.

Operation was performed in one stage for drainage. The patient was improved. The origin of the condition was not determined. The temperature on admission was 99.4 F. (Figs. 7, 8 and 9).

CASE 11.—D. M. (patient of Dr. Martin), was admitted, March 20, 1922. He was acutely ill all the time. There was massive necrosis of almost the entire upper lobe. No examination of sputum for tubercle bacilli was made. He died three weeks after inception of the trouble, which began as pneumonia (Fig. 10).

CASE 12.—N., woman (patient of Dr. Green), referred by Dr. Bastedo, was admitted in April, 1922, three weeks after a tonsillectomy. A two-stage operation was performed for drainage, and the abscess was opened by packing gauze into the lung on the abscess. Examination of sputum was negative for tubercle bacilli. The operation was performed three weeks after the onset, and the patient is still improving and is still in the hospital ward, improved.

Our thanks are due to Dr. Patterson, Dr. Mathews, Dr. Bastedo and Dr. Martin for allowing us to include their cases among these in this paper, and to Dr. D. E. Ehrlich for referring three valuable cases to us.

LUNG ABSCESS *

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I shall include under the heading abscess of the lung all types and degrees of abscess, except those due to tuberculosis and bronchiectasis, and all degrees of gangrene of the lung except a massive gangrene involving an entire lobe or lung. Because localized gangrenous abscess is so difficult to differentiate from a pure pyogenic abscess, symptomatically, and even at necropsy, and because it is usually impossible to determine whether one has supervened on the other or preceded it, I shall consider the so-called gangrenous abscess as a type of lung abscess per se rather than as a distinct entity.

There are few conditions which, arising often from such trivial and preventable causes as does abscess of the lung, so quickly and completely incapacitate a person, rendering him a burden to himself, his friends and to society. The progressive weakness, the distressing cough, the long convalescence and, above all, the foul smelling and tasting sputum, break the morale of the stoutest patient and present one of the most difficult conditions to treat.

HISTORY

The history of lung abscess should be read at length by those interested in its treatment. Hippocrates [1] recognized the condition and pointed out that at times the abscess burst into a bronchus and was spat up, and that occasionally it ruptured into the pleural cavity, necessitating drainage.

Since his time, medical literature has abounded in recorded cases of lung abscess. Drainage by cautery puncture, intercostal stab and thoracotomy has been employed since the earliest times. Antiseptic injections and irrigation through the bronchial tree have been practiced. There have been alternate periods of active surgical treatment and of a return to more palliative measures.

A decided advance was made in 1885 when Gluck, Schmidt, Block and Biondi [2] showed, for the first time, that partial resection of the

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* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

1. Hippocrates, quoted by Koch: Historisches über die chirurgische Behandlung der Lungencavernen, Berl. klin. Wchnschr. **11**:194-196, 1874.

2. Gluck, Schmidt, Block and Biondi: Die Entwickelung der Lungenchirurgie, Arch. f. klin. Chir. **83**:581-601, 1907.

lungs was possible in animals. In 1894, for the first time, pneumothorax was employed for the treatment of a tuberculous abscess, by Forlanini.[3]

Tuffier, Garrè and Quincke did a great deal toward stimulating the more logical study of the condition. McKewan's total extirpation of a lung, under chloroform anesthesia, should have marked an epoch in thoracic surgery, but, unfortunately, it seems to have been overlooked by the profession at large. Murphy,[4] in his address on thoracic surgery, in Denver, in 1898, was twenty years ahead of his time. Sauerbruch, Meyer, Lilienthal, Robinson and many others have made most valuable contributions to the subject.

ETIOLOGY

The predisposing and direct causes of this condition are well recognized by all members of this society. Particularly, I would emphasize the incidence of lung abscess following operation in the region of the nose and throat when a general anesthetic has been employed. In these days when tonsillectomy is so lightly advised and so frequently employed, it should be pointed out to the profession that lung abscess is not a rare sequel, nor one lightly to be entertained. It should be appreciated that it has occurred almost entirely in patients operated on under general anesthesia. Richardson,[5] in 1912, first pointed out this phenomenon. Bassin,[6] in 1913, collected the reports of sixteen cases following tonsillectomy under general anesthesia. Manges[7] saw nine cases in one year at Mount Sinai Hospital. Wessler[8] states that 28 per cent. of the cases of lung abscess seen in the roentgenographic department of Mount Sinai Hospital were due to tonsillectomy. Pottenger[9] reported having seen, in eighteen months, twenty cases following tonsillectomy. Of thirty-two lung abscesses reported by Whittemore,[10]

3. Forlanini, C.: Ein Fall von seit sechs Jahren bestehendem durch kunstlichen Pneumothorax behandeltem Lungenabszess, München. med. Wchnschr. **47**:124-129, 1910.

4. Murphy, J. B.: Surgery of the Lung, J. A. M. A. **31**:208 (July 30) 1898; ibid. 281 (Aug. 6) 1898; ibid. 341 (Aug. 13) 1898.

5. Richardson, C. W.: Complications of the Operation for Removal of Tonsils, Laryngoscope **23**:667-678, 1913.

6. Bassin, C. G.: Les complications broncho-pulmonaires consécutives à l'adénoidectomie et à l'amygdalectomie, Paris, Muller, 1913.

7. Manges, M.: The Occurrence of Abscess of the Lung After Tonsillectomy; with a Report of Nine Cases in Adults, Am. J. Surg. **30**:78-83 (March) 1916.

8. Wessler, H.: Suppuration and Gangrene of the Lung. A Study of One Hundred Cases, J. A. M. A. **73**:1918 (Dec. 27) 1919.

9. Pottenger, F. M.: Points of Differential Diagnostic Value in Pulmonary Abscess, Bronchiectasis and Pulmonary Tuberculosis, with an Explanation of the Cause of the Difference in Auscultatory Findings, Am. J. Med. Sc. **158**: 502-510 (Oct.) 1919.

10. Whittemore, W.: Lung Abscess, Surg. Clinics N. Am. **1**:765-784 (June) 1921.

in 1921, seventeen followed tonsillectomy. Of fifty-four cases that came to the Mayo Clinic, sixteen were due to tonsillectomy. Of 208 collected cases of lung abscess following tonsillectomy, we find only seven in which operation was performed under local anesthesia. Twenty-five thousand tonsillectomies have been performed at the Mayo Clinic under local anesthesia, and only one lung abscess has occurred. That was a terminal process in a pyemia and should not be considered as a true post-tonsillectomy lung abscess. Surely this is irrefutable evidence that the abolition or slowing of the pharyngeal reflex under general anesthesia, by allowing inhalation of infected débris, is the important factor in the etiology. A fractional percentage of the lung abscesses following tonsillectomy are embolic in origin, but the great majority are due to aspiration of the caseous, bacteria-laden content of the tonsils.

Contrary to textbook dictums, lung abscess is a rare sequel of lobar pneumonia. It is probably more common following bronchopneumonia. Aspiration of foreign bodies accounts for a certain percentage of abscesses. A few follow traumatism. Emboli from a distant focus, such as an infected middle ear or a thrombosed lateral sinus, is a definite cause. A few develop from pulmonary embolus.

Time will not permit me to go into the morbid anatomy, pathology and bacteriology of the disease further than to point out a working classification into large and small, single and multiple, acute and chronic, simple acute and acute gangrenous and simple chronic and chronic putrid types. It might also be pointed out that no analogy can be drawn between abscess in the lungs and in any other part of the body.

LOCATION OF ABSCESSES

It is important to realize that lung abscess occurs about two and one-half times as often on the right as on the left side, and about twice as often in the lower lobes as in the upper. The exact location varies, however, with the etiology. About 80 per cent. are peripherally situated and about one-fourth are multiple, but in most cases confined to the same portion of lung.

SYMPTOMS

The symptoms vary with the etiology, the general resistance of the patient, the duration of the disease and the extent of pulmonary involvement.

When cough, dyspnea, pain in the chest and the raising of foul sputum are added to the disease or are prolonged after the period that the ordinary affection of the lung or respiratory tract usually persists, abscess should be suspected. Following tonsillectomy and other opera-

tions about the nose and throat, foul expectoration is usually produced between the tenth and fifteenth days.

Regardless of the cause, loss of appetite, progressive loss of weight, emaciation, general weakness, pallor, productive cough, foul sputum, pain in the chest, variable dyspnea, fluctuating temperature and leukocytosis characterize the disease. Clubbing of the fingers and watch crystal nails occur. The hemoglobin is reduced in chronic cases. In most cases, the red count is low. Rigors occur at some stage. Fifty per cent. of patients have blood in the sputum at some time during the course of the disease. In our cases, it was rare to find elastic tissue in the sputum, though it is usually considered the sine qua non of the disease.

The atypical and recurrent types of the disease must be borne in mind.

LOCATION OF ABSCESS

Location	Patients	Per Cent.
Right side	381 of 537	71
Left side	156 of 537	29
Upper lobes	157 of 447	35
Lower lobes	266 of 447	60
Middle lobe	24 of 447	5
Right upper lobe	40 of 193	21
Middle lobe	24 of 193	12
Lower lobe	67 of 193	35
Left upper lobe	13 of 193	7
Left lower lobe	49 of 193	25
Acute	95 of 221	43
Chronic	126 of 221	57
Peripheral	56 of 71	79

DIAGNOSIS

It is a disease of symptoms rather than physical signs. The diagnosis depends on the history, the roentgen-ray findings, examination of the sputum and the general physical examination. On an accurate history, only the majority of lung abscesses can be diagnosed. The affection is three times as common in males as in females. It may occur at any age, but occurs usually between the ages of 25 and 40 years. While a careful physical examination is necessary, thorough fluoroscopic examination and stereoscopic roentgenograms are essential. Roentgenographic examination serves to differentiate tuberculosis, bronchiectasis, empyema, cysts, gangrene, malignancy, aneurysm, etc.

Needling of a pulmonary abscess as a diagnostic method is mentioned only to be condemned.

The bronchoscope should be used, especially if there is any question of the patient's having aspirated something, and, in any case, if the abscess is not draining freely through a bronchus.

COMPLICATIONS

The complications may be many and may be more serious than the disease. Cerebral embolus and pulmonary hemorrhage are especially serious.

PROGNOSIS

The prognosis must be guarded, depending on the cause, the extent of lung involvement, the complications, the patient's general resistance and the treatment adopted. Abscesses following tonsillectomy offer a more favorable prognosis than those following aspiration of foreign bodies, such as pieces of metal, kernels of corn, and so forth. Metallic bodies have some inherent property of producing gangrenous abscesses. Abscesses due to bronchopneumonia are so often multiple that the prognosis is unfavorable. Embolic types are usually serious. Apical abscesses are more favorable than those located in the middle or lower lobes.

TREATMENT

Every patient should be given a thorough trial on medical regimen, with postural drainage, before other methods of treatment are adopted. One should persevere with patients until some position is found in which free bronchial drainage is established. Once this position is found, the necessity of frequently assuming this position in order to keep the cavity empty should be carefully explained to the patient.

Inhalations should be employed, not so much for their curative effect per se as to offset the odor, thereby improving the patient's mental outlook and his desire for food. The careful use of the bronchoscope to dilate the main bronchus leading from the abscess, thereby facilitating postural drainage, might be advisable.

If, after a fair trial of this method, the temperature is still elevated and the patient is not eating better, is not coughing less or producing less sputum and is not gaining generally, other measures should be considered.

Artificial pneumothorax should be tried for the small encapsulated abscess not connected with a bronchus, and perhaps for the ordinary long-standing, well localized abscess.

The indications for operation are:

1. Operation should be undertaken for all patients who, after a thorough trial of medical treatment are no longer improving or holding their own.

2. Early operation is advisable in all cases of fair sized patent cavities surrounded by markedly fibrosed or calcareous walls.

3. If pneumothorax fails to effect a cure in the small encapsulated abscess not connected with a bronchus, operation should be undertaken early.

4. After thorough medical treatment to put the patient in the best possible condition for operation, surgery should be resorted to in all patients in whom an abscess surrounds a foreign body embedded in the parenchyma, or in whom a foreign body lodged in a bronchus cannot be removed through a bronchoscope.

5. Operation is advisable in patients with a very large cavity, producing large amounts of fluid, in whom the danger of drowning themselves in their own sputum is to be feared.

Surgical Treatment.—Resection and direct drainage should be employed in patients who are very dangerously ill. In patients who will stand it, a thoracotomy should be performed. The abscess or abscesses should be localized by thorough palpation. It, or they, should be marsupialized, and at the earliest possible moment closed over with skin flaps from the chest wall. Bearing in mind the relative position of the lobes, the incision should be planned in such a way as to allow direct and easiest access to the area involved.

Resection en masse of a small, completely encapsulated abscess and of a portion of the lung with a foreign body implanted in it is the method of choice.

The danger of postoperative hemorrhage, empyema and cerebral emboli should be avoided.

MORTALITY

In adults, the mortality rate in recorded cases has averaged 58 per cent. after medical treatment and 35 per cent. in those treated surgically. In children, it has been much higher.

Of fifty-four patients whose cases I have recently reported, twenty-seven were treated surgically and twenty-seven medically. Forty-nine were chronic cases. The average duration of symptoms was nineteen weeks before examination. Twenty-five were of the type classed as gangrenous abscess. In sixteen, the complications were almost as serious as the disease itself. Of the twenty-seven patients treated medically, sixteen were cured, three improved, five not improved and three are dead. Of the twenty-seven patients treated surgically, thirteen are cured, three improved with fistulas, and eleven are dead. Analysis of the eleven deaths reveals the extent of the disease before coming for treatment, and the impossibility of averting death in a certain percentage of long neglected cases.

The greatest danger in medical treatment is that the time is not recognized when medical treatment should give way to surgical.

CONCLUSIONS

1. Contrary to the opinion of the early writers that abscess of the lung is a common sequel to lobar pneumonia, a survey of the reported

cases of the last century would lead one to conclude that it is a rare sequel.

2. By lowering the resistance in the lung tissue itself, lobar pneumonia, bronchopneumonia and influenzal pneumonia predispose the patient to the development of lung abscess following pyogenic infection.

3. Lung abscess occurs more often betwen the ages of 25 and 40. It is three times as common in males as in females; it occurs two and one-half times as often on the right side as on the left, and about twice as often in the lower lobe as in the upper. Three out of four cases are peripheral and involve the pleura, and one out of four is multiple.

4. It must be borne in mind that, recently, a high percentage of lung abscesses have been the result of neglect or mismanagement on the part of the nose and throat surgeons, the oral surgeons and the dentists. Such neglect or mismanagement is manifested in the selection of the anesthetic, in not keeping the patient's head low and in not taking sufficient precautions to prevent the patient from inhaling foreign matter. Such a sequel may be avoided by (1) employing a local anesthetic whenever possible in surgery of the mouth, nose and throat, and in teeth extraction; (2) keeping the head low during such operations if a general anesthetic is employed, until the patient has thoroughly aroused from it; (3) taking care to prevent blood and mucus from accumulating in the throat and being aspirated, and (4) better hemostasis in such work.

5. The diagnosis depends on the history, the amount and nature of the sputum, the roentgen-ray and physical examinations.

6. A study of results in these cases has led me to conclude that surgery should not be employed so soon as the diagnosis has been made, except as indicated. The mortality has been unnecessarily high in many instances. Instead, thorough medical treatment, with postural rest and drainage, should be instituted. When this fails, pneumothorax should be produced in selected cases, and surgery reserved for those patients who do not respond to the other two methods.

7. The exploratory needle should not be employed.

8. When surgery is decided on, paravertebral and local anesthesia, if necessary with gas and oxygen, should be used; and, in the majority of patients, a more deliberate, extensive and logical operation should be planned than resection of the chest wall over the abscess, and cautery or blunt puncture of the abscess.

9. If the patient's condition is such that extensive operation would involve too much risk, resection, blunt puncture and exploration of the abscess with the finger should be the limit of surgery.

10. The surgeon, physician and roentgenologist should be intimately associated in making the diagnosis and in the care of these patients.

THE SURGICAL TREATMENT OF BRONCHIECTASIS

WITH A REPORT OF THREE CASES OF REMOVAL OF A LOBE OF THE LUNG *

EVARTS A. GRAHAM, M.D.
ST. LOUIS

Existing methods of treating bronchiectasis are far from satisfactory. In general, the radical methods are associated with a high mortality, and the less radical ones accomplish little. Improvements will come probably through accumulated experience. With the view of adding to the total of recorded experience, three cases are here presented. Various measures which have been used are: (1) pneumotomy, with an attempt to drain a cavity; (2) thoracoplasty; (3) ligation of branches of the pulmonary artery, a method suggested by Sauerbruch [1] to produce shrinkage of the affected portion of the lung; (4) artificial pneumothorax; (5) partial pneumectomy. It is evident that three general principles underlie all of the methods of treatment enumerated above. These are drainage, compression or shrinkage, and excision. Some cases which are associated with a foreign body in the lung will show great improvement after its removal, especially if it is lodged in one of the larger bronchi and if it can be removed through a bronchoscope. Here again, however, we are dealing with a method which probably owes its success largely to drainage.

In any advanced case of bronchiectasis, the bronchioles and some of the larger bronchi are not only enormously enlarged, but their walls are also greatly thickened by fibrosis, as a result of long-standing inflammation. It would seem unlikely, therefore, that much could be expected either from the establishment of open drainage or from any procedure which was aimed at compression of the affected portion of the lung. Open drainage in such cases, with the creation of a bronchial fistula, will frequently diminish the amount of sputum and will give some relief; but I have never seen a patient made well by such a method. In fact, it would seem difficult to understand how complete healing could occur. It is probable that cases of patients reported as made well by such a method have really been lung abscess rather than bronchiectasis. Methods based on the principle of compression or

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* From the Department of Surgery, Washington University School of Medicine.

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1. Sauerbruch: Die Bronchiectasen, Cong. de la Soc. Internat. de chir. Rap. 1911, p. 269.

shrinkage of the lung cannot be expected to accomplish much in advanced cases because of the extreme fibrosis of the affected bronchi. In fairly early cases, however, compression with artificial pneumothorax will sometimes yield excellent results. Dr. J. J. Singer and I now have under observation a patient who has gained more than 50 pounds (22.7 kg.) in weight and who has been free from all symptoms for more than a year as a result of using artificial pneumothorax at intervals. This case may be one of bronchiectatic abscess of the type so designated by Lilienthal [2] and by Aschner.[3] Sauerbruch's method of ligation of branches of the pulmonary artery obtained results which were certainly not strikingly successful. The method does not seem to be a good one. In another case, Dr. Singer and I saw a temporary beneficial effect following an exploratory operation and a partial thoracoplasty consisting of the extensive removal of three ribs over the affected lobe.

If the case is one in which there is a more or less general dilatation of the bronchi and bronchioles in a lobe, probably the only procedure which, on rational grounds, can be expected to give complete relief is extirpation of the diseased portion. This implies usually the extirpation of at least one lobe, for the reasons that most often the whole lobe is affected, and also that it is generally easier technically to remove the whole lobe than it would be to attempt to find only the portion which might be involved. Unfortunately, however, lobectomy has been associated with a high mortality, and the results have not always been satisfactory even when the patient has survived the operation. Less radical measures than lobectomy, however, have also been unsatisfactory and have likewise been associated with high mortalities. Summaries of results from the literature are likely to be confusing because, probably in many cases, there has been no sharp differentiation between a case of lung abscess which was communicating with a bronchus and a case of bronchiectasis. This must have been so particularly before the use of the roentgen ray.

Quincke [4] summarized fifteen cases treated almost entirely by incision into the lung. Of these patients, one was entirely healed; six (40 per cent.) were improved; two (13 per cent.) remained unhealed, and six (40 per cent.) died as a direct result of the operation. Thus, 53 per cent. were either unhealed or died. Tuffier's [4] compilation of results is given in Table 1.

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2. Lilienthal, Howard: Resection of the Lung for Suppurative Infections, with a Report Based on Thirty-One Operative Cases in Which Resection was Done or Intended, Ann. Surg. **75**:257 (March) 1922.

3. Aschner, P. W.: A Pathological Study of the Material, Ann. Surg. **75**: 318 (March) 1922.

4. Quoted by Sauerbruch, Footnote 1.

Sauerbruch,[1] in 1911, found that of 123 patients with bronchiectasis who were treated by pneumotomy, forty (33 per cent.) were said to have been healed; seven (6 per cent.) were improved; thirty-three (27 per cent.) were unhealed, and forty-three (35 per cent.) died.

Heidenhain [5] seems to have been the first to undertake deliberately the removal of a lobe of the lung for bronchiectasis. He successfully removed the left lower lobe after two previous operations had been performed for drainage. A permanent bronchial fistula remained, however. In 1914, Willy Meyer [6] found that sixteen cases had been reported in which pneumectomy had been performed for bronchiectasis. Of this number, eight patients were classed as cured or improved, and eight died. In 1915, he reported the case of another patient on whom he operated successfully. Robinson,[7] in 1917, reported seven cases with three deaths. It is uncertain, however, how many of these cases were entirely successful from the standpoint of freedom from symptoms, complete healing, etc. Lilienthal [2] has recently contributed a summary of his very remarkable experience. This work constitutes the largest

Compilation of Results Obtained by Tuffier

Operation	Cases	Improved or Healed	Died	Mortality, Per Cent.
Pneumotomy	38	28	10	26.3
Pneumectomy	1	0	1	100
Thoracoplasty	1	0	1	100
Puncture (trocar).....	5	3	2	40

single experience with lobectomy in bronchiectasis which has been reported by any surgeon. Although his article deals with thirty-one cases of suppurative infections of the lung in which resection was either performed or intended, it deals actually with twenty-one cases diagnosed as bronchiectasis in which a resection of a portion of the lung was performed. Of this number, seven patients (33 per cent.) were reported as well; twelve (57 per cent.) died, and, of the remaining two patients, one was reported as convalescent and the other as still having cough and expectoration. Also, one of the patients classified as well still had a small fistula.

5. Heidenhain: Augedehnte Lungenresektion wegen Zahlricher eiternder Bronchiektasen in einen Unterlappen, Verhandl. d. deutsch. Gesellsch. f. Chir. **30**:636, 1901.

6. Meyer, Willy: On Bronchiectasis, Tr. Am. Surg. A. **32**:592, 1914.

7. Robinson, Samuel: The Surgery of Bronchiectasis; Including a Report of Five Complete Resections of the Lower Lobe of the Lung, with One Death, Surg. Gynec. & Obst. **24**:194 (Feb.) 1917; The Resection of the Lobes of the Lung, Discussion, J. A. M. A. **69**:355 (Aug. 4) 1917.

Including the three cases of my own reported here, it becomes evident that the literature contains reports of forty-eight cases of bronchiectasis in which resection has been performed. Of this number, twenty-five patients have died, presumably as a result of the operation, a total operative mortality, therefore, of 52 per cent. Probably, however, isolated fatalities have occurred here and there which have not been reported, so that the operative mortality has perhaps been actually higher than 52 per cent. Furthermore, not all of the patients that have survived the operation can be considered well. In 1917, Smith and Mudd [8] carefully analyzed the cases reported up to that time, and they considered that only three could be regarded as complete successes, two of Lilienthal's and one of Robinson's. It would appear now, however, that in six cases of Lilienthal's complete series there have been perfectly satisfactory results and in one of my own. This then would make eight complete successes out of forty-eight cases in which resection has been performed. In other words, in only 17 per cent. have complete successes occurred.

The natural query, therefore, is: Should the operation be considered a justifiable one? I believe that it is justifiable in properly selected cases, because the misery of many of those afflicted with the condition is beyond description. In most of the advanced cases, the patients are social outcasts, unable to find employment or to enjoy ordinary human associations. To many of them, death would come as a welcome relief from their misery, and, indeed, some of the patients threaten suicide if they cannot be given relief. In a series of twenty-one cases of bronchiectasis studied by Dr. J. J. Singer and myself, no less than six patients have implored us to perform a resection in spite of being fully informed as to its dangers. In three of the cases, we have refused because we felt that the proper indications for the operation were not present. Moreover, almost certainly the operation will become safer with improved technic. Present methods will be supplanted by improvements which will greatly reduce the mortality.

What are the indications? There seems to be a rather general agreement that at present, in the undeveloped state of the technic of resection, the most important indications are: (1) failure of more conservative methods; (2) age, not too advanced, preferably under 35 years; (3) restriction of the process to one lung, and preferably to one lobe; (4) absence of other conditions which would themselves greatly increase the hazard of the operation; (5) performance of the operation by one who is experienced in thoracic surgery; a tyro will almost surely fail.

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8. Smith, E., and Mudd, H.: A Modification in Method of Pneumotomy for Bronchiectasis, Tr. A. Am. Phys. **32**:313, 1917.

What sort of lobectomy shall be performed? There are, in general, two methods of approach to the lung, one through an intercostal incision, and the other after a preliminary resection of ribs. The former method has been used extensively by Lilienthal in performing a one-stage resection, and the latter was used by Robinson in the performance of a multiple-stage resection. The advantage of the former method is that it leaves less deformity; but its disadvantages are that it does not provide so good an opportunity for a multiple-stage operation and often does not afford so good an exposure as the latter. The details of the technic of each method have been described by Lilienthal [2] and by Robinson,[7] respectively.

The causes of the high mortality from a resection of part of the lung in cases of bronchiectasis are many. They seem to be either immediate or late. Of the immediate causes, the chief seem to have been respiratory failure, cardiac failure, hemorrhage and shock. Respiratory failure is not likely to occur if there are strong adhesions between the unaffected lobe on the side on which operation was performed and the chest wall, or if care is taken not to have too large a free opening. These findings are in accord with former work done by R. D. Bell and myself,[9] in connection with the mechanics of open pneumothorax. Diminishing the size of the opening by the use of gauze compresses or by delivering the lobe outside will usually overcome any respiratory embarassment which may occur during the operation. After the operation, it is desirable to exclude the free entrance of air by applying a fairly firm pad of dressings over the wound. This procedure will tend to minimize the dyspnea which may occur immediately after the operation. It seems to me that one of the advantages of a multiple-stage operation is that it is possible at one stage to create adhesions between the unaffected lobe and the chest wall before proceeding to the resection of the affected lobe. Robinson showed that, by packing gauze around the affected lobe, adhesions will be produced between the other lobe and the chest wall, which will be sufficiently firm in a week or ten days to permit the resection without breaking up the desired adhesions. I have found, however, that sometimes a longer time is required. In order to be sure, therefore, of firm adhesions, a period of about two weeks should elapse. Respiratory failure during the operation, even in a case without adhesions, may be minimized also by a proper kind of anesthesia. To accomplish this, the anesthetic may be given through a catheter into the pharynx, with a little pressure supplied by a foot

9. Graham, E. A., and Bell, R. D.: Open Pneumothorax: Its Relation to the Treatment of Empyema, Am. J. M. Sci. **56**:839 (Dec.) 1918. Graham, E. A.: The Importance of the Vital Capacity in Thoracic Surgery, J. A. M. A. **75**:992 (Oct. 9) 1920.

bellows or a mechanical pump; or, if gas is used, a tightly fitting face mask will accomplish a perfectly satisfactory inflation of the lungs. My own choice for intrathoracic work is the latter method.

The sudden cardiac failure which sometimes occurs in these operations is perhaps partly due to manipulation of the heart and sudden changes in its position. Almost invariably after the operation, the pulse rate becomes high; a rate of 150 is not uncommon. To combat this high pulse, Lilienthal has recommended that digitalis be given in sufficient amounts before the operation and over a long enough period of time to obtain a good digitalis effect. Serious hemorrhage is not a common complication; but, nevertheless, it is wise, before the operation, to make all necessary arrangements for a transfusion of blood.

COMPLICATIONS

Of the late complications of the operation, infection is most serious. It is this complication which probably is responsible for most of the deaths. Infection seems to be unavoidable. At least, for the sake of safety, in each case, infection should be expected and provision made for drainage. The stump of the lung after the resection always contains virulent bacteria, and there is no method by which it can be sterilized. So far as I am aware, every case has developed a bronchial fistula if death did not occur too soon. This, however, has usually closed spontaneously. Efforts, therefore, should be directed toward minimizing the effects of infection. If only a small portion of the pleural cavity becomes infected, the results will be less serious than if practically the whole pleural cavity is exposed. This fact, to my mind, constitutes another important reason for not performing a resection in the presence of a free pleural cavity. It serves to emphasize the importance of having part of the pleural cavity first obliterated by the creation of adhesions between the unaffected portion of the lung and the chest wall. This constitutes, it seems to me, an argument in favor of an operation based on the principles of the one devised by Robinson. For, by a multiple-stage operation, it is possible to create adhesions at the desired places by temporarily packing in gauze at one stage of the operation. In Case 2, I believe the result might have been different if strong adhesions had existed between the unaffected portion of the lung and the chest wall, so that that portion of the pleural cavity would have been obliterated. The presence of sufficiently strong adhesions to obliterate the portion of the pleural cavity occupied by the unaffected portion of the lung is desirable, both from the standpoint of minimizing respiratory difficulties and of minimizing infection.

The mediastinal space is also likely to be infected in some cases. This may be due, in part, to a retraction of the stump of the bronchus, if care is not taken to avoid it. In my three cases, I attempted to avoid

it by leaving clamps on the pedicle, the handles of which projected from the wound and firmly anchored the root of the lobe for about four days, until adhesions could form. Lilienthal has left his ligatures long, so that they could be brought out of the wound and anchored. Infection may also spread into the pericardium, and there may also be a severe infection of the remaining portion of lung as well as of the other lung. Here again, it would seem possible to create a leukocytic wall of defense in the pericardium and the mediastinal pleura before exposing these structures to contamination by the contents of the stump of the bronchus. It is to be expected that such a result would occur as an effect of the gauze packing introduced in a stage preliminary to the resection, for the purpose of creating adhesions between the unaffected portion of lung and the chest wall. Another point of importance in connection with the question of infection is the amount of necrotic tissue present. In order to avoid the danger of late hemorrhage from the stump, it is wise to leave a considerable portion of lung tissue (from 0.5 to 1 cm.) beyond the ligatures or the clamps. Unless provision for adequate drainage is made, this necrotic tissue, harboring various anaerobic organisms, will become a serious menace. In view of the more recently developed chemical theories of shock (compare summary by Cannon [10]), necrotic tissue must be regarded as constituting a serious menace to life if its products can be absorbed.

It would seem to be desirable to use early and frequent irrigations with surgical solution of chlorinated soda (Dakin's solution) in order both to inhibit the development of infection and to hasten the separation of the necrotic tissue. There are certain difficulties, however, connected with its systematic use in all cases. For the first day or two, these patients are likely to be extremely uncomfortable, and it seems doubtful how wise it is to subject them to even the slight disturbance associated with the systematic use of irrigations by the Dakin-Carrel method. Later, a bronchial fistula develops, and then it is difficult to avoid flooding the bronchus with the solution.

Progress in the technic of resection of the lung will probably come about largely through development of methods which will minimize the inevitable infection. Any procedure which will permit the easy and safe creation of firm adhesions between the unaffected portion of lung and the chest wall will serve greatly to reduce the mortality of the operation, for the double benefit of a minimum of pleural cavity to be infected and a minimal amount of respiratory disturbance during and immediately after the operation will result.

Records of three cases are presented in which lobectomy has been performed. The essential features of the operative procedure are given

10. Cannon, W. B.: Studies in Experimental Traumatic Shock: IV. Evidence of a Toxic Factor in Wound Shock, Arch. Surg. **4**:1 (Jan.) 1922.

in the respective case reports. In each case, the anesthesia was produced by nitrous oxid and oxygen, through a closely fitting face mask, preceded by a hypodermic injection of morphin, ¼ grain (0.0162 gm.), and atropin, 1/100 grain (0.00065 gm.). After the operation in each case, morphin was given freely to control the pain.

REPORT OF CASES

CASE 1.—A boy, aged 17, entered Barnes Hospital, Nov. 1, 1920, referred to me by Dr. J. J. Singer, who had made a diagnosis of bronchiectasis involving the left lower lobe. For fifteen years, the patient had had a chronic cough. For the last two years, this had been worse and had been accompanied by expectoration of a large amount of offensive sputum. This amounted to nearly a pint of sputum a day. It was usually yellowish green and occasionally

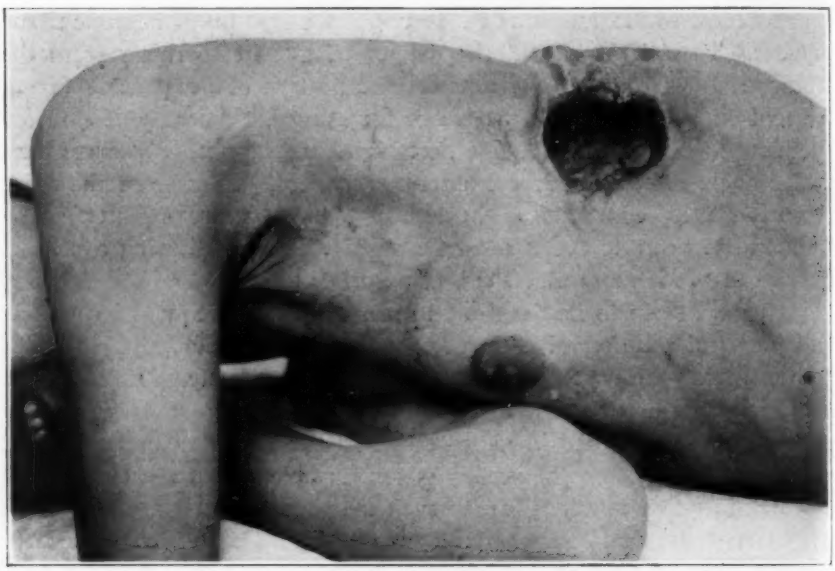

Fig. 2 (Case 1).—Patient, six weeks after operation. A bronchial fistula was present at this time.

streaked with blood. There had been no active hemorrhage. There was no pain. The appetite was good. The patient had learned to free himself of sputum by bending over. Coughing started the flow, which continued until the sputum was expelled. He had been treated, about a year previously, in the Jewish Hospital by Dr. Sale, who made a pneumothorax on the left side. He received no benefit from this treatment and stated that he felt worse as a result of it, because since then he had had pain in the chest. He had spent several months in Colorado without result. His sputum had been examined repeatedly for tubercle bacilli with negative results. He had had measles at 5 years of age and whooping cough at 6 years. There was no evidence of pneumonia at the time of the onset of the chronic cough, beginning at the age of 2.

Fig. 1 (Case 1).—Left lower lobe from Case 1 after resection. Almost every bronchiole is enormously thickened and dilated. The cyanotic color of the lobe is characteristic.

Examination.—The patient was fairly well nourished and somewhat cyanotic. He weighed 131.5 pounds (59.7 kg.), and was 5 feet 9¾ inches (177 cm.) tall. The shoulders were stooped; the expression was listless. There was marked clubbing of the fingers and toes, prominent mammary glands, offensive breath, slight asymmetry of the chest. The left side of the chest was flattened, with limited expansion. The left clavicle was slightly more prominent than the right. The chest circumference on the left side was 17.25 inches (43.8 cm.); right side, 18 inches (45.7 cm.), expansion, 1 inch (2.5 cm.). Tactile fremitus was decreased on the entire left side. There was dulness over the left lower

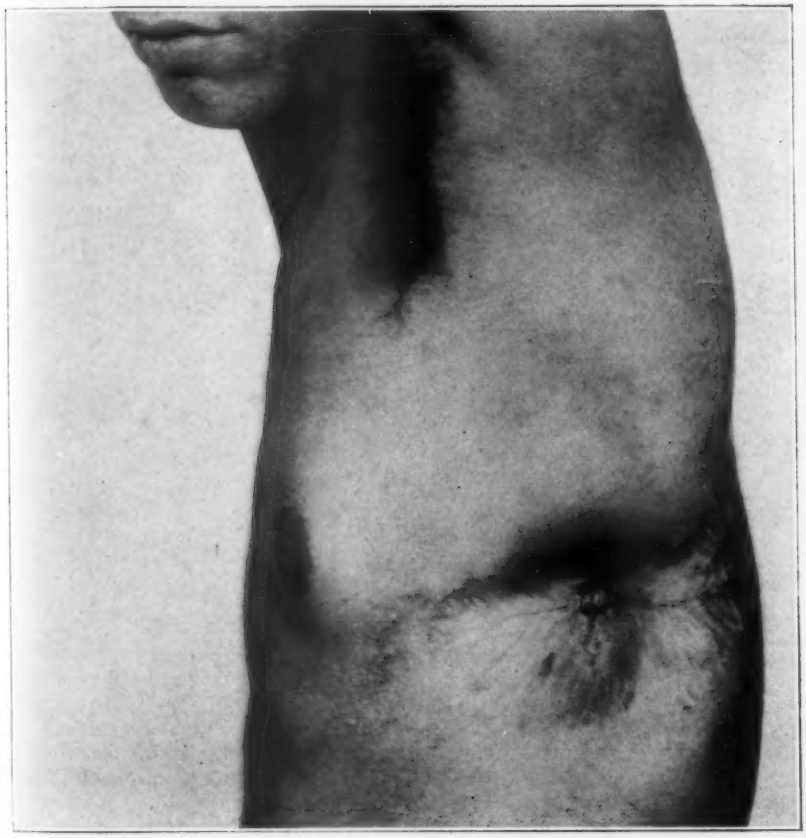

Fig. 3.—Wound completely healed, three months later.

lobe. The heart was displaced somewhat to the left; there were no murmurs, but there was slight sinus arrhythmia. The blood pressure was: systolic, 110, and diastolic, 65. The liver was slightly palpable in the epigastrium. The reflexes were all present. The Wassermann reaction was negative. The temperature was 98.2 F.; the pulse, 80; respirations, 18; hemoglobin, 90 per cent.; red cells, 5,040,000; leukocytes, 9,580. The urine was normal. The electrocardiogram was normal. The roentgen ray revealed an extensive infiltration of the left lung toward the base, with displacement of the heart to the left. There was an area of pneumothorax in the left apex.

Operation.—November 6, the first-stage operation was performed. About 5 inches (12.7 cm.) of each of the seventh, eighth and ninth ribs was resected on the left side, from the angles to the mammary line. The corresponding intercostal bundles were excised. The pleura was noticeably thickened and was not opened. The first stage terminated after closing the skin with silkworm and silk sutures, without drainage. There was no marked reaction to the first-stage operation, but elevation of temperature of 1 degree, and a faint trace of albumin in the urine, with a few hyaline and granular casts. Healing occurred by primary intention. November 22, the old flap was turned up; the

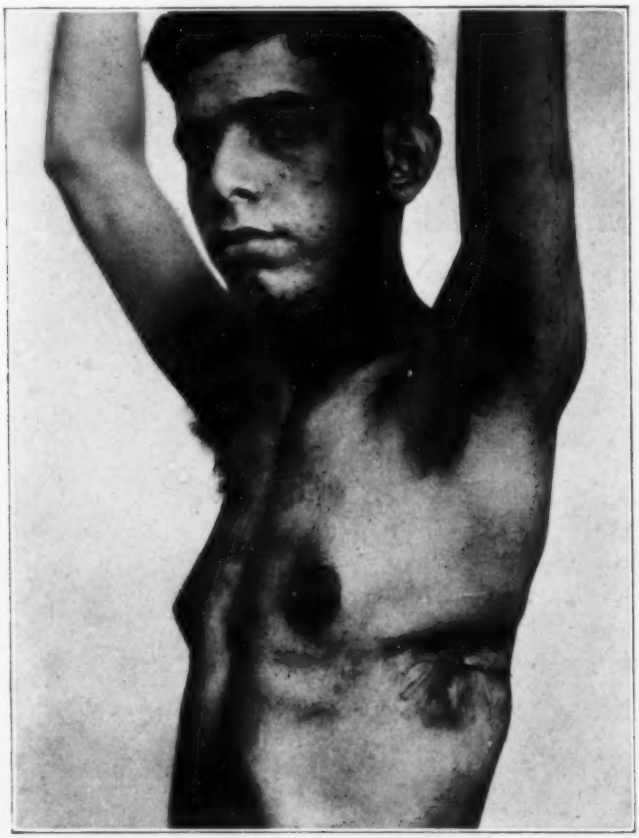

Fig. 4.—One year after the operation. There is no impairment of motion of the arm.

pleura was opened, with but little change in the respiration at first. Adhesions between the upper lobe and the chest wall were so delicate that separation occurred when the finger was introduced into pleural cavity. The pleura was about one-half inch (1.27 cm.) thick. There were extensive adhesions between the diaphragm and lung. The lower lobe was dark, firm and nodular. Adhesions between the lung and diaphragm and chest wall were broken up with the finger. Gauze soaked in petrolatum was packed about the lower lobe. The second stage was terminated. The reaction was more severe after the

second stage than after the first. The temperature on the following day was 101 F.; pulse, 110; respiration, 22. There was considerable discharge of bloody serum. On the sixth day after operation, the packing from the chest was removed, under nitrous oxid anesthesia, and three Carrel tubes were inserted for irrigation with Dakin's solution. The temperature continued to be elevated, reaching a height of 104 F., until the ninth day after operation (Dec. 1), when it fell to practically normal and remained so until the third stage of the operation. December 14, the patient weighed 117 pounds (53 kg.).

The cavity was kept clean after the first two or three days by irrigation with the Dakin solution, and, December 31, the third stage of the operation was carried out. With nitrous oxid anesthesia, the old incision was reopened and the lung was found to have retracted upward somewhat. In order to provide more space, about 4 inches (10 cm.) of each of the fifth and sixth ribs was removed. The lower lobe was densely adherent all around. Many adhesions had to be cut. The greatest difficulty was in separating the

Fig. 5.—Anterior and posterior views of patient, showing healed scar and extent of deformity.

adhesions between the lung and the diaphragm. The separation between the upper and middle lobes was easy. Curved clamps were placed on the hilum, and the lobe was amputated. The clamps were left in position. The wound was packed with petrolatum gauze and covered with several pads to exclude air. The operation was well tolerated and lasted forty-five minutes. January 3, the clamps were removed from the hilum without bleeding and with no evidence of bronchial fistula. There had been very little reaction to this stage of the operation. The maximum temperature was 102 F., with an average of about 100 F. The average pulse rate was 130; respiration, 25. There was no cough. Dakin irrigations were continued regularly from the time of removal of the clamps. January 8, the patient tasted Dakin's solution for the first time and began to cough during irrigation. January 10, a bronchial fistula was observed. Instead of ordinary Dakin's irrigations, one irrigation a day was substituted, with the patient in the sitting posture, care being taken

to avoid entrance of fluid into the fistula. Recovery was practically uneventful except for an attack of acute tonsillitis. He was discharged from the hospital, February 19, with a bronchial fistula about the size of a lead pencil. This healed entirely spontaneously, about two months later. It has remained healed ever since. There has been practically no cough since the operation, and the patient is now able to work for the first time in about three years. He also indulges in athletics and has become an amateur boxer of considerable ability.

CASE 2.—A man, aged 25, had symptoms which had begun five years previously with a severe cough. About six months later, he began raising, every day, about one-half cupful of sputum, which was sometimes dark brown and other times white. The condition had continued until the time of examination; in fact, the symptoms were at that time more distressing than they had ever been. He then raised from 2 to 3 cupfuls of sputum in twenty-four hours. The sputum had a very foul odor. Beginning in 1917, for a period of about

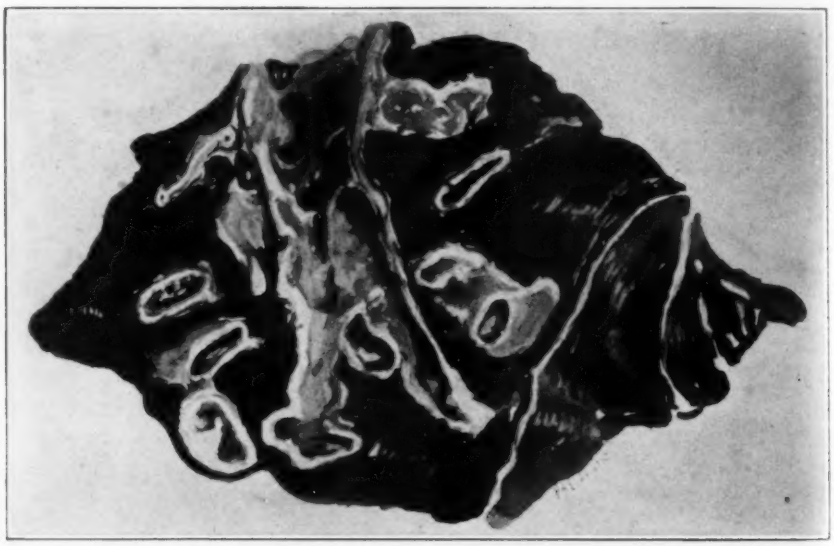

Fig. 6 (Case 2).—Resected lobe.

three years, he was treated for pulmonary tuberculosis at several sanatoriums in the far west. He had not been able to work much during the last four years. He was from 10 to 15 pounds (4.5 to 6.8 kg.) under normal weight. Chills and fever had been frequent, until, during the last year, he discovered how to drain his lungs by gravity. His family history and previous history were of no particular importance.

Examination.—This indicated involvement of the left lower lobe. There was moderate clubbing of the fingers and toes. The temperature, pulse and respirations were normal. The urine was normal except for a slight trace of albumin on one occasion. There was slight secondary anemia; red cells, 4,000,000; hemoglobin, 79 per cent.; leukocytes, 10,000. The Wassermann reaction was negative. *Staphylococcus albus* and *Streptococcus viridans* were found in the sputum. The vital capacity measured 5,250 c.c.; the tidal-air 400 c.c.

Operation.—Sept. 9, 1921, a crescentic incision was made, with convexity downward, beginning about 1½ inches (3.8 cm.) from the spine, at the level of

the fifth rib, passing downward to cross the eighth interspace in the scapular line, coming up again to the fifth rib in the anterior axillary line. The seventh, eighth and ninth ribs reflected subperiosteally from a point slightly posterior to their angles to a point about 1 inch (2.5 cm.) anterior to the anterior axillary line. The muscle bundles were then excised. The upper lobe could be seen to move on respiration. The pleura was not opened but was swabbed with tincture of iodin with the idea of establishing adhesions between the upper lobe and the chest wall. The flap was turned down and sutured without drainage. After the operation, pads were placed over the wound and anchored firmly in position by means of long adhesive strips in order to create a buttress as a support for the patient's coughing. Convalescence after this first stage was uneventful. It is interesting to note that, September 22, the vital capacity was only 2,750 c.c. as compared with 5,200 c.c. before operation. September 23, the flap of skin and soft parts was turned up, the pleura opened and the lower lobe found to be densely adherent. It was separated from its attachments with great difficulty. The most troublesome adhesions were between the lung and the diaphragm, on the one hand, and the lung and the posterior wall, on the other. The adhesions to the pericardium caused little trouble. The interlobar fissure was completely obliterated, but was finally detected by a thin, black line, and separation was accomplished with the finger. Even after the separation of the lower lobe, no marked difficulty with respiration occurred; it was assumed, therefore, that the upper lobe was probably adherent. A large kidney clamp was put on the pedicle to the lower lobe and clamped tightly. Four small clamps were left on bleeding adhesions which were difficult to tie without consuming a considerable amount of time. The lobe was then removed. At that time, it was evident that the adhesions between the upper lobe and the chest wall had been very delicate and had been separated during the manipulation necessary to remove the lower lobe. The clamps were left in place and gauze was packed into the wound. The time of the operation was fifty minutes. The anesthetic was nitrous oxid and oxygen. Immediately after the operation, the pulse rose to 150; respirations, 26; temperature, normal. The pulse rapidly decreased to 110; but, during the next few days, the respirations continued to increase in number, and the pulse remained high, averaging about 120. Morphin was given liberally. The clamps were removed on the third day after operation without hemorrhage. September 29, coarse bubbles and a friction sound were heard all over the right side, from the fourth rib down. Leukocytes increased to 15,000 and finally to 27,000. Death occurred, September 29. Irrigation of the pleural cavity with Dakin's solution had been attempted early; but it seemed to cause marked discomfort to the patient. It had, therefore, been abandoned, with the expectation of continuing it later.

Necropsy.—The upper lobe of the left lung was found to be entirely free, and there was, therefore, generalized infection of the left pleural cavity. In addition, there was fibrinopurulent pericarditis. The right lung was edematous.

Comment.—In reviewing this case, it seems apparent that the patient would have had a better opportunity to survive if there had been firm adhesions between the upper lobe and the chest wall. The advantages would have been those which have already been enumerated in the text above. This case illustrates in a forceful way the importance and desirability of having adhesions between the unaffected portion of the lung and the chest wall.

CASE 3.—A man, aged 29, entered Barnes Hospital, March 11, 1922. He was referred by Dr. V. P. Blair, who had corrected a facial defect. He gave a history of pneumonia in 1918, when he was with the American Expeditionary

Forces. Pneumonia followed a shell wound involving chiefly the face. There was no wound of the thorax. Following the pneumonia, fluid was obtained several times from the chest by aspiration, but no operation was performed. A cough had been present ever since that time. He now coughed up from about 300 to 400 c.c. of sputum a day. This had a very foul odor; was thick and heavy, and the patient stated that it looked like pus. He frequently had slight fever and chills. Since returning from France, he had spent his time constantly in hospitals. There was rather marked clubbing of the fingers and toes. The physical signs were not striking, but indicated that the involvement

Fig. 7 (Case 3).—Resected lobe.

was in the right lower lobe. There was slight impairment of the percussion note on the right side, from the third rib down. Breath sounds were slightly suppressed over the right base. The roentgenograms revealed a shadow just to the right of the sternum in the lower thorax, which suggested slightly an abscess. Aspiration of this suspicious area with a needle revealed nothing. A bronchoscopic examination by Dr. Arbuckle disclosed no foreign body and indicated that the pus was apparently coming from the right lower lobe. March 18, Dr. J. J. Singer performed an artificial pneumothorax; 400 c.c. of air was injected into the right pleural cavity, changing the pressure from a former

one of from —6 to —4 to one of from —5 to —2. During the next two days, the patient raised more sputum than before, but he complained of some discomfort in the right thorax. March 22, roentgenograms demonstrated that there was not a satisfactory collapse of the lung. The question of radical operation was discussed with the patient, and he was acquainted fully with its dangers and possibilities. In arriving at a decision for operation, he informed me he would much rather be dead than remain alive in his present condition; that he was, therefore, willing to take any chance, no matter how great, to become well.

Operation.—April 8, a first-stage operation was performed similar to that described in Cases 1 and 2 except that the pleura was opened in order to inspect the conditions present. The lower lobe was found to be dark blue. The upper and middle lobes were of normal color. The lower lobe was adherent to the diaphragm and to the pericardium by strong fibrous adhesions. It was much more solid to the touch than the upper two lobes. There were no adhesions between the upper and middle lobes and the chest wall. The lower lobe was, therefore, packed off with petrolatum gauze after the adhesions were liberated, in order to delay the rest of the operation until after adhesions had formed between the upper part of the lung and the chest wall. The packing was removed, April 13, under nitrous oxid anesthesia. The wound looked clean. The middle lobe was clearly adherent to the lateral wall. There was still a large space between the pericardium and lung which was not obliterated. The lower lobe looked small, and still appeared to be isolated nicely. Two Carrel tubes were inserted into the cavity to prevent infection by irrigation. More gauze was put in loosely in order to overcome a slight degree of dyspnea which occurred after the removal of the packing. During the next three weeks, the wound became clean, and remained so. The patient became comfortable after a temporary period of discomfort. One month after the first stage, he was given a transfusion of 550 c.c. of blood, preliminary to the lobe resection. The transfusion was performed because the patient had a slight secondary anemia (hemaglobin, 80 per cent.). On the day following the transfusion, the resection was carried out. The lower lobe was found to be densely adherent, and the separation was extremely difficult because of the dense adhesions to the diaphragm and the pericardium. Some tearing of the lung occurred during the separation, and there was hemorrhage to the extent of about 250 c.c. Two large curved clamps were placed on the hilum, which immediately controlled the bleeding. The lobe was then cut away. No sutures or ligatures were placed, except three silkworm sutures through the skin. The wound was packed lightly with petrolatum gauze. The duration of the operation was thirty minutes. Anesthesia was accomplished under nitrous oxid and oxygen, by Dr. Hawthorne. Immediately following the operation, the patient was again transfused. He received 700 c.c. of blood. Two days after the operation, an attempt was made to remove one of the large clamps; but bleeding occurred and the clamp was reapplied. For the first three days the patient's condition seemed to be excellent. On the fourth day after operation, however, he had a severe chill, which lasted for fifteen minutes. He died on the fifth day following the resection, with a temperature of 104 F., which had been present for twenty-four hours. Previous to that, the temperature and pulse had been nearly normal.

Necropsy.—A partial necropsy was permitted, but not until after the body had been embalmed. An extensive lobular pneumonia was found, involving both the right and the left lung.

SUMMARY

In advanced cases of bronchiectasis, the only method which seems to offer a chance of complete relief from all symptoms is a resection of the affected portion of the lung. The mortality has been high in the few cases reported. The literature contains records of forty-eight cases, with a total operative mortality of 52 per cent. It is probable, however, that improvements in method will greatly reduce the mortality. Even with this high mortality, the striking results obtained in the successful cases seem to justify the risk incurred in properly selected cases. The unspeakable misery of patients with advanced bronchiectasis leads them often to grasp at any straw which offers relief, regardless of the risk involved. It has been difficult in some of our cases to refuse operation when we have felt that the proper indications were not present.

LUNG ABSCESS *

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In the records of the Surgical Service of the Johns Hopkins Hospital, there are sixty-two cases of lung abscess. It is our purpose briefly to summarize these cases in order to present to you what our experience with lung abscess has been.

Etiologically, these cases may be divided into four groups:

1. Thirty-one cases followed pneumonia associated with, or unassociated with, empyema.

2. Sixteen cases were postoperative, in the sense that they followed a postoperative bronchopneumonia or the aspiration of some infectious material. Four cases followed tonsillectomy; seven, intra-abdominal operations; two followed mastoid operations, and one, each, a hernia, an open reduction of a fracture and a breast operation.

3. Seven cases followed acute abdominal infections, of which four were liver abscesses secondary to acute abdominal infections; one a pelvic peritonitis, and two subphrenic abscesses secondary to appendicitis.

4. Eight cases followed a miscellaneous group of conditions. Two followed the aspiration of a tooth; two the perforation into the lung of an esophageal carcinoma; one an abortion with septicemia, and three a septicemia secondary to acute osteomyelitis, multiple arthritis and umbilical cord infection.

These four groups of cases will be considered in more detail.

GROUP 1.—POSTPNEUMONIC GROUP—THIRTY-ONE CASES

Of these thirty-one cases, four were not recognized during life. In these, pneumonia was followed by empyema, which obscured the diagnosis. These patients were operated on for empyema and died. Necropsies in all showed bilateral multiple lung abscesses, conditions which could not have been satisfactorily treated by surgery.

In the remaining twenty-seven cases in this group, the diagnosis of lung abscess was made. The abscesses occurred in the right upper lobe in five cases, in the left upper lobe in two cases, in the right lower lobe in eight cases, in the left lower lobe in ten cases, and were multiple in the right lung in two cases. The condition was associated with empyema in ten cases and was not associated with empyema in seventeen cases.

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* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

The treatment carried out in these twenty-seven cases was as follows: In twenty-two cases, a simple drainage operation was performed, either in one or two stages. In one case, an exploratory thoracotomy was followed by artificial pneumothorax. In one case, a drainage operation was followed by a lobectomy. In three cases, postural treatment by Garvin's method was tried.

Following these various forms of treatment, six patients died, a mortality of 22.2 per cent. Five patients died after drainage operations, and in four of them a necropsy was obtained. In three, the necropsy revealed multiple lung abscesses, only one of which had been drained at operation. In one, the necropsy revealed an acute spreading gangrene, which involved the entire right lung. One patient died after a lobectomy performed some months after a drainage operation. Necropsy demonstrated that death was due to an extensive bronchopneumonia.

Of the twenty-one patients who recovered, all were discharged from the hospital practically free from symptoms. In twelve, we know the late result. Ten are well from one to ten years after operation, entirely without symptoms. Two are active and consider themselves well; but it is evident that they have some cough and expectoration. In nine, we do not know the late result; but the study was not begun until recently, and we have hopes of tracing some of these patients.

Of the four patients treated either by artificial pneumothorax or by postural methods, we know the late result in two. One is perfectly well; one still has some cough and expectoration but considers himself so well that he does not need further treatment.

GROUP 2.—POSTOPERATIVE GROUP — SIXTEEN CASES

Of these sixteen cases, five were not recognized during life. Two patients died some time after mastoid operations; one died after a gastro-enterostomy; one after an enterostomy, and one after an open reduction of a fracture of the femur. Necropsies in all revealed multiple lung abscesses.

In the remaining eleven cases, the diagnosis of lung abscess was made. The abscesses occurred in the left upper lobe in two cases, in the right lower lobe in four cases, in the left lower lobe in three cases, and in two cases they were multiple. The condition was not associated with empyema.

The treatment carried out in these eleven cases was as follows: In six cases, a simple drainage operation was performed. In four cases, exploratory thoracotomy was followed by artificial pneumothorax. In one case, no treatment was permitted, the patient refusing operation.

Three patients died following drainage operations. In two of the three cases, necropsies were performed, which revealed multiple lung abscesses, only one of which had been drained.

Of the eight patients who left the hospital, seven were free from symptoms, while one left the hospital untreated. In four cases, we know the late result. One patient is entirely well, several years after collapse treatment; three are in good health, two or more years after operation, but are not entirely well, as indicated by cough and slight expectoration.

Of the four patients treated by collapse therapy, only one has been heard from. He is perfectly well.

GROUP 3.—ABDOMINAL INFECTIONS GROUP — SEVEN CASES

Of these seven cases, two were not recognized during life. One patient died some time after an operation for liver abscess, and one after an operation for peritonitis and subphrenic abscess. The symptoms and signs of lung abscess were not clear. Necropsies in both cases revealed multiple lung abscesses.

In the remaining five cases in this group, the condition was recognized and treatment instituted. The abscess occurred in the right lower lobe in four cases, and in one, it involved almost the entire right lung. The condition was associated with empyema in one case and was unassociated with empyema in four cases.

The treatment carried out in these five cases was drainage in one or two stages. Following operation, one patient died. Necropsy revealed a healed liver abscess and an enormous lung abscess involving almost the entire right lung.

The four patients who recovered left the hospital practically free from symptoms. In two, the late result is known, and these two patients are entirely well, two or more years after operation. Two patients have not been heard from.

GROUP 4.—MISCELLANEOUS GROUP — EIGHT CASES

Of these eight cases, three were not recognized during life. One patient died some time after an operation for acute osteomyelitis, one after the drainage of several joints, and one after the drainage of an empyema. All showed, at necropsy, multiple lung abscesses.

In the remaining five cases, the condition of lung abscess was recognized. The abscess occurred in the right lower lobe in four cases and in the left lower lobe in one case. It was associated with empyema in one case, and unassociated with empyema in four cases.

The treatment carried out was drainage in one or two stages in three cases and lobectomy in one case. One patient refused operation or other treatment.

Following operation, three patients died. Necropsies in these three cases revealed an extensive carcinoma of the esophagus with extension into, and with the formation of, lung abscess in two. One patient, in whom lobectomy was performed, died of a pleural infection.

The late result in the two patients that left the hospital is not known at present.

SUMMARY

1. Of sixty-two cases of lung abscess in our surgical records, fourteen were unrecognized during life. Necropsies in these fourteen cases revealed, in every instance, multiple small abscesses scattered throughout the lungs, conditions which could not have been satisfactorily treated by surgery.

2. In the remaining forty-eight cases, lung abscesses were recognized. In these, the abscess or abscesses followed pneumonia in twenty-seven cases; they were complications following some surgical operation in eleven cases; they followed acute abdominal infections in five cases, and were complications of a miscellaneous group of conditions in five cases. The abscesses occurred in the right upper lobe in five cases; in the left upper lobe, in four cases; in the right lower lobe, in twenty-one cases; in the left lower lobe, in fourteen cases, and were multiple in four cases. The abscesses were associated with empyema in twelve cases and were not associated with empyema in thirty-six cases.

3. The treatment of these forty-eight cases consisted of: (*a*) drainage in one or two stages in thirty-six cases; (*b*) drainage followed by lobectomy in two cases; (*c*) exploratory thoracotomy and collapse therapy in five cases; (*d*) postural treatment (Garvin's method) in three cases, and (*e*) no treatment in two cases.

Forty-three patients, therefore, were subjected to forty-five operations. Following operation, there were thirteen deaths, an operative mortality of 28.8 per cent. Eleven deaths followed drainage operation, and necropsies in these eleven cases showed that: (*a*) in six cases, there were multiple pulmonary abscesses, only one of which was drained at operation; (*b*) in one case, there was a consolidation, with softening and abscess formation involving the entire lung; (*c*) in one case, there was an acute spreading gangrene involving the entire lung; (*d*) in one case, there was an extensive bronchopneumonia in addition to the abscess, and (*e*) in two cases, there was an extensive inoperable carcinoma of the esophagus, with extension into the lung and with abscess formation.

Two deaths followed lobectomy, performed some months after a drainage operation. Necropsies revealed that one death was due to an extensive bronchopneumonia and the other to a pleural infection—not the result of leakage from the bronchial stump, but presumably the result of tearing into an infected lung during the separation of adhesions.

4. The end-results in the thirty-five patients who recovered and who were discharged from the hospital have not yet been so thoroughly worked up as they will be. At the present time, however, they are

as follows: (*a*) Of the twenty-five patients who recovered following drainage operations, eleven have been well from one to ten years or more —entirely without symptoms; four have not been entirely well from one to ten years—they have some cough and slight expectoration. Ten have not yet been heard from. (*b*) Of the five patients who recovered following exploratory thoracotomy, plus collapse by artificial pneumothorax, two have been well from one to ten or more years, three have not yet been heard from. (*c*) Of the three treated by postural methods (Garvin), one is not entirely well, having still some cough and expectoration, and two have not been heard from. (*d*) Of the two patients who refused operation or other treatment, neither has been heard from.

Such, then, has been our experience with lung abscess as it has occurred in a general surgical service. There has been no attempt to eliminate any cases nor to gloss over our results. Our experience simply demonstrates that lung abscess as seen in a general service occurs as a complication of many conditions and presents itself in a variety of forms. As has been shown, it may be overshadowed by other conditions and escape recognition (fourteen cases), later presenting itself at necropsy in the form of numerous small scattered abscesses quite unfavorable from the standpoint of surgical treatment. It may be recognizable, but it may occur in multiple form so as to defeat our surgical efforts—as in six of our cases. It may be a complication of a hopeless condition, as in our two cases of carcinoma of the esophagus, in which the only justification for surgical treatment was the hope of relieving the patient of distressing cough, foul sputum and sepsis. Undoubtedly, surgery at the present time achieves good results only in those single, well-circumscribed abscesses in which the condition of which they are a complication has disappeared. If we consider only these as lung abscesses amenable to surgical treatment, then our results are vastly improved. If we eliminate from our series the cases of multiple abscesses, and those with some serious intra-abdominal or mediastinal condition present at the time operation for lung abscess was performed, in other words, if we confine ourselves to the single, well-circumscribed abscesses in otherwise healthy individuals, then we have twenty-nine cases of lung abscess treated by drainage, in one or two stages in twenty-four cases, and by exploratory thoractomy followed by artificial pneumothorax in five cases—with one death from spreading gangrene of the lung; a mortality of 3.4 per cent. The late results in these selected twenty-nine cases are: Thirteen patients are entirely well; three patients are not entirely well, as they have some cough and slight expectoration, and eleven patients have not yet been heard from.

Let us conclude with two remarks on our personal experience in the treatment of lung abscess. A partial artificial pneumothorax

followed by roentgenograms of the thorax to determine, in doubtful cases, the presence or absence and the location of adhesions to the parietal pleura would seem a safe and helpful procedure. Stripping the parietal pleura from the thoracic wall over the point of approach, we have found to be a very useful preliminary step in the drainage of lung abscesses. It enables one to explore the lung over a considerable area, in order to determine to what extent adhesions are present and the location of the best point to open the abscess. It better enables one to fix the lung to the parietal pleura if adhesions are absent.

A study of our late results so far as they have gone demonstrates that it is the old, long-standing chronic lung abscess, with thick fibrous walls, which is often not entirely cured by drainage operations. The patients in our series that we know are well are those with acute or recent lung abscesses. The four patients that we know are not entirely well all had chronic abscesses of from two to seven years' standing which at operation presented thick fibrous walls.

THE INTERRELATIONSHIP AND END-RESULTS OF CHRONIC SUPPURATIVE DISEASES OF THE LUNGS*

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The end-results of acute or chronic disease of the lung may be classified into: (1) resolution to normal conditions; (2) fibrosis, and (3) necrosis. Which of these may be the end-result of any illness depends on the factors of resistance and the character of the noxa, chemical, bacterial or mechanical, that has been the causative agent in the production of the malady. Thus, come into being the three main diseases that constitute the suppurative type of pulmonary disease, namely, empyema, bronchiectasis and abscess. Acute pulmonary disease which proceeds into chronic disease may be classified into seven groups:

Group 1. Acute fulminating inflammations that may be caused by irritating gases; these rapidly fuse with later groups unless death ensues.

Group 2. Acute streptococcal bronchopneumonia, common during the epidemic of influenza.

Group 3. Less acute, but almost equally fatal, pseudolobar pneumonia, also of streptococcal or pneumostreptococcal origin.

Group 4. Pneumonia progressing to the formation of free or interlobar encysted empyema.

Group 5. Abscesses of the unilocular or multilocular type, or acute bronchiectasis. Included in this group are abscesses of embolic origin, and the aspiration type of bronchiectatic abscess.

Group 6. Residual inflammation which develops into chronic nontuberculous infection of the lung, or into frank bronchiectasis.

Group 7. A resolving condition gradually reverting to normal.

In Group 4 are the greatest number of patients whose conditions are of long standing, and whose deformities and disabilities we are most often called on to treat. I have observed many such patients within the last three years, and almost invariably a fistula discharging pus gives evidence of former operation. If there is much granulation tissue in the sinus and projecting from it into the chest wall, the

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* From the Section on Medicine, Mayo Clinic.

* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

discharge is more or less bloody. There are five explanations of this chronicity:

1. The treatment of tuberculous empyema by open methods, or by methods designed for the treatment of nontuberculous forms. Hedblom [1] and McKinnie [2] have outlined the necessary precautions to be used in conditions such as tuberculous empyema, from the standpoint of both diagnosis and operation. The latter says, "Assuming a purulent effusion of the pleura, not definitely metapneumonic or post-influenzal, the greatest care should be used to exclude tuberculosis before instituting open drainage, since cases of empyema showing no tubercle bacilli almost universally heal promptly, while those having tubercle bacilli rarely do so." Even with the utmost care, however, errors in diagnosis will be made, and untoward results will probably follow in a small proportion of cases representing a diagnostic error which by care may be reduced.

2. The sinus itself may lead from infected tissue, have thickened walls and remain open indefinitely.

3. At the base of the sinus there may be an infected rib, and osteomyelitis may be the cause of chronicity.

4. The drainage may have been insufficient.

5. The surgical wound may have been made in an improper position.

Inasmuch as all purulent effusions tend to form adhesions, whereas air and transudates do not, pockets are formed, the pleura is thickened and the lung does not expand properly to fill the pleural space. Added to this, bronchial fistulas or multiple fistulas are obvious causes of chronicity. Fibrosis is one of the end-results of infection. The fibrosis may become sufficiently extensive to cover the lung with a coat of mail, effectually preventing reexpansion. Thickened trabeculae give the appearance of fibrous bands invading the lung which is affected by inflammatory processes and constitute one of the three processes of general or massive fibrosis, namely, (*a*) fibrosis of the pleura associated with fibrosis within the lung; (*b*) fibrosis extending from the hilum, and (*c*) fibrosis within the lung, and proceeding throughout the interlobular septums or around the bronchi and vessels, or in the alveolar walls.

Such a result must necessarily cause changes in the chest itself. Patients are now under my observation who have unilateral shrinkage of the wall of the chest, with loss of mobility, obliterated interspaces, lowered shoulder and scoliosis, the convexity toward the sound side. Besides this deformity, a resultant flattening and immobility of the

1. Hedblom, C. A.: The Diagnosis and Treatment of Tuberculous Empyema, Surg., Gynec. and Obst. **34**:445-465, 1922.

2. McKinnie, L. H.: Tuberculous Empyema, J. A. M. A. **78**:400-402 (Feb. 11) 1922.

diaphragm may be seen on fluoroscopic examination, the importance of which has not been sufficiently emphasized clinically. Fibrosis, whether tuberculous or nontuberculous in character, constitutes one of the agencies which produce changes in position of the mediastinal structures, the most obvious of which are the heart and the trachea.

One of the interesting accompaniments of suppurative disease of the lung is the peculiar deformity of the extremities. I have observed

Fig. 1.—Appearance of patient at time of operation.

all degrees from simple clubbing, or hippocratic deformity, to true pulmonary osteo-arthropathy, with the characteristic burring of the terminal phalanges and periosteal overgrowth extending far up the long bones of the upper and lower extremities. Clubbing of fingers is not necessarily confined to pulmonary disease, nor is it always bilateral. I have seen, within the year, unilateral clubbing in a case of aneurysm of the innominate artery. Locke [3] has made the most complete

3. Locke, E. A.: Secondary Hypertrophic Osteo-Arthropathy and Its Relation to Simple Club-Fingers, Arch. Int. Med. **15**:659-713 (May) 1915.

study of this condition from a statistical and roentgen-ray standpoint and has recorded cases that seem to be primary rather than secondary in character.

In the unfortunate cases in which errors in diagnosis have been made and patients with tuberculosis operated on, amyloidosis or tuberculous meningitis has been a fatal complication. Such conditions must be reckoned with in operative procedures producing collapse of the

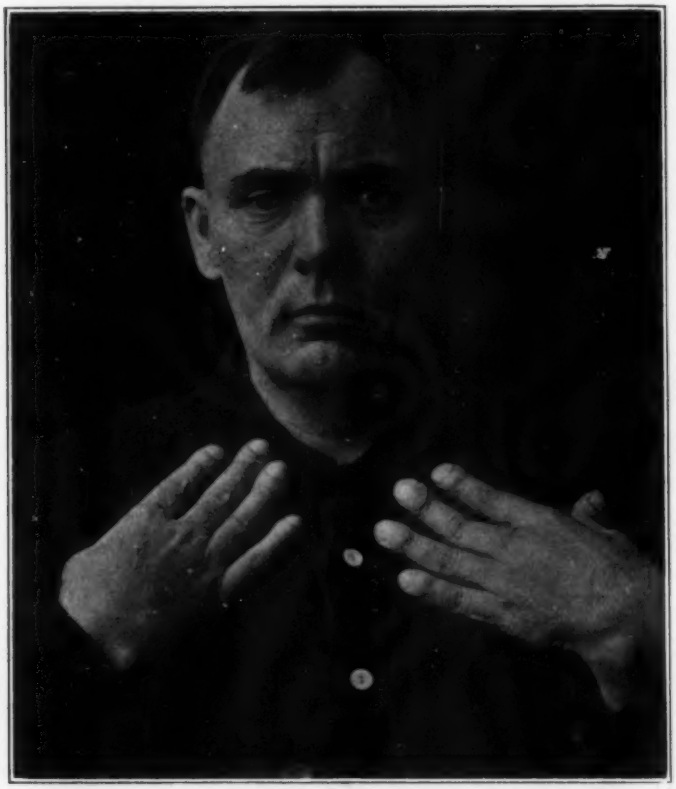

Fig. 2.—Appearance of patient, three months after operation; gain in weight of 40 pounds (18 kg.).

lung in cases of unilateral tuberculosis, particularly if the disease has been of long duration.

The case reported herewith is an illustration of the difficulty of diagnosis in long-standing chronic pulmonary suppuration; it also illustrates the benefit that can be obtained by surgical intervention.

REPORT OF CASE

History.—W. R. S., man, came to the clinic, Dec. 13, 1921, complaining of pain in the chest, persistent cough, excessive sputum, hemorrhage and deformity of the fingers, wrists and ankles. He had apparently been

powerfully built, but now showed evidence of severe and long-continued illness. He had had influenza three years before, during a time when the scarcity of physicians in his outlying country did not permit him to have careful attention. It was thought that the influenza had been complicated by pneumonia; there was a history of pain which could be construed as that of pleurisy. The primary illness kept him in bed for about five months, although he had partially recovered within the first few weeks. He had continued to be an invalid from that time. A profuse hemorrhage had occurred September 16, and again

Fig. 3.—Thickened cortex in the shaft of the femur; fused bony and periosteal changes.

he was forced to his bed, where he remained for two months. For a long time, he had had increased temperature, which usually reached its height about 3 p. m. It had not been more than 100 F. since August. He had noticed clubbing of the fingers for the last two years. His wrists were crippled, and his feet swollen and stiffened, so that he was unable to dress himself alone, or to walk.

Examination.—The patient had come for examination in a wheel chair and continued to use it during the time he was under observation before operation. He was examined in this chair or on a couch to which he was carried. He was not weighed at the time of his first examination; but he had weighed 220

pounds (100 kg.) in normal health. The blood pressure was 112 systolic, and 72 diastolic. The pulse was 132 and the temperature 100 F., at 3:00 p. m. He showed evidence of advanced dental infection, but his tonsils apparently were normal. The hair was crisp, short, wiry and rather scant, and the skin was dry over the entire body, with some exfoliation over the face. The heart was large, the apex beat being 5 cm. outside the nipple line. The chest was remarkably asymmetrical, the deformity consisting of flattening of the entire right side with absent Litten's sign, almost fixed diaphragm and very limited respiratory excursion throughout the right side. The percussion note over the

Fig. 4.—Porosity of lower third of humerus.

chest was dull, but moist râles could be heard throughout, although the breath sounds were distant. He had arthritis in both knee joints. The femur on the right side was remarkably enlarged; there was limited movement in the ankle joints and noticeable hyperextension of the fingers. Roentgenograms of the chest revealed empyema on the right side, with a shadow resembling fluid which reached the level of the second rib in front. Roentgenograms of the bones revealed evidences of slight arthritis, marked proliferative osteitis in the hip joints and proliferative osteitis of the bones of the extremities. The history and examination pointed to the subjoined conclusions with regard to the chronology of the infection:

Influenza had occurred, complicated by bronchopneumonia, with succeeding empyema. The empyema cavity had formed a fistula with the bronchus, and continuous expectoration of large amounts of purulent material had resulted.

Operation and Result.—Operation was performed December 20, and 2.75 cm. of the seventh rib was resected. After several attempts, pus was aspirated by needle, the tract running inward and slightly upward to a depth of about 7.5 cm. from the pleura. Free pus was not found in the pleural cavity itself although the parietal pleura was thickened. By blunt dissection along the

Fig. 5.—Roughened cortex due to periosteal proliferation.

course of the needle, a cavity was opened, about 8 or 10 cm. in diameter, containing pus mixed with blood. The cavity was sponged out and explored by the aid of a small light, placed inside. The cavity was so deep, however, that the walls could not be seen. The surgeon was of the opinion that he was dealing with a deep-seated abscess of the lung. The patient coughed up considerable bloody material at the time of operation; but, after the institution of drainage, there was no further coughing. The wound was treated in the usual manner. About three weeks later, the drainage tract was dilated, and three tubes were again inserted.

The patient recovered uneventfully, and was markedly improved. He was able to walk without help; he no longer coughed; the amount of sputum was reduced practically to nothing, and he gained about 40 pounds (18 kg.) in weight before his dismissal.

COMMENT

This case is an illustration of the fact that if patients continue to be ill after the primary infection should have been overcome, it must be assumed that they are suffering from suppurative disease which should be attacked at once. The case also illustrates the importance of the surgeon's exact knowledge of the anatomy of the lung, the pleura

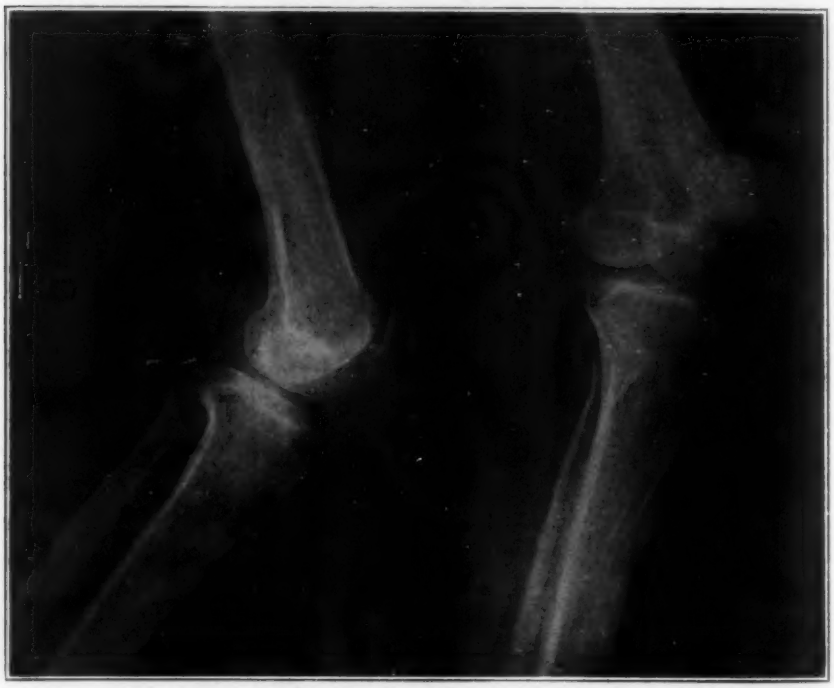

Fig. 6.—Rarefaction of head of tibia; periosteal proliferation of the shaft of femur.

and of the interlobar markings, because such suppuration may be found in any location in which two surfaces of pleura meet. Although a surgical diagnosis of abscess was made in this case, the possibility was considered of encapsulated empyema lying deep between the lobes, and forming with the bronchus a fistula which provided the profuse drainage seen at the primary examination.

Because of the fibrosis and the persistence of cough, particularly in patients who have developed bronchial fistula, even if successful operations have been performed, bronchiectasis must be reckoned with. This is true for two reasons: first, because the strength-giving wall of the

bronchus itself may have been primarily involved in the original disease of the lung, as almost invariably occurs in diseases of influenzal origin, and, therefore, gives way under the added pressure due to cough, and, second, in the fibrous lung the damaged bronchus has lost its normal elastic support and dilates when the interbronchial pressure is raised (McPhedran [4]). This result is more likely to follow when the pleura

Fig. 7.—*A*, periosteal proliferation; *B*, porosity at distal ends of radius and ulna.

anchors the lung to the chest wall, a condition present in the majority of my patients suffering from bronchiectasis. Hoover says, however:

> It seems probable that, in cases of bronchiectasis accompanying fibroid disease, destructive inflammatory process of the bronchial wall is the primary lesion. That the idea of a tractive diverticulum may have some merit can be granted, but it is not susceptible of direct proof.

4. McPhedran, A.: Diseases of the Bronchi, in Osler and McCrae: Modern Medicine, Philadelphia, Lea and Febiger **2**:881-944, 1914.

There are two other factors which may enter into bronchiectasis: One is traction on the bronchi from inspiratory movement of the thorax, and the other is an increase of endobronchial pressure which accompanies effort at coughing. That the endobronchial pressure is raised with the effort of coughing is evident enough, but, if endobronchial pressure is to explain bronchiectasis, then extrabronchial pressure over the site of bronchiectasis must be very much less than the endobronchial pressure during the act of coughing. If endobronchial pressure does not exceed extrabronchial pressure in the expiratory effort, the act of coughing could not contribute to dilatation of the bronchi.

In my experience with influenza, bronchiectasis did not develop for six months or a year after the acute illness. In only one instance

Fig. 8.—Flexion deformity; osteoporosis.

could a diagnosis of acute bronchiectasis be made with accuracy. The time required was made necessary by the disintegration of the integrity of the bronchial wall and the subsequent formation of fibrous tissue.

Norris and Landis [5] say:

In regard to pulmonary fibrosis and bronchiectasis, it is not a question of distinguishing between them but of determining whether the two conditions are associated. Both are due to the same cause. In about 80 per cent. of the

5. Norris, G. W., and Landis, H. R. M.: Diseases of the Chest, and the Principles of Physical Diagnosis, Philadelphia, W. B. Saunders Company, 1920.

cases of massive fibroids, the bronchi are dilated. Rarely the bronchi are dilated without associated interstitial changes in the pulmonary tissue. In a case with marked unilateral retraction of the chest wall, there are also a paroxysmal cough, profuse expectoration, often of a foul odor, and marked clubbing of the fingers. It is reasonably certain that in addition to the fibroid changes the bronchi are also dilated.

It is important to recognize the relationship between abscess and bronchiectasis because often the abscess in the process of healing may

Fig. 9.—Fluid level at second rib; right costophrenic angle obliterated; left costophrenic angle free.

provide conditions that are necessary for the production of bronchiectasis, and, alternately, by the occurrence of acute infection to which sufferers from bronchiectasis are prone, abscess may develop. Bronchopneumonia is not an unusual complication of bronchiectasis. I have known it to occur repeatedly in several of my patients. The end-results vary only slightly from those of empyema; inhalation may produce a

septic bronchopneumonia-gangrene in the lung tissue. Abscess of the brain is not an uncommon complication, and amyloid changes appear in the liver and kidneys.

Improvement in bronchiectasis may occur even in severe cases, whether unilateral and treated by operative collapse or bilateral and under medical management. Conner [6] has recently studied a patient

Fig. 10.—Condition of lung one month after operation.

with bilateral bronchiectasis who had an unusually large amount of chyloid sputum and who improved remarkably under medical management. Hedblom [7] has operated in unilateral cases, with very encouraging results.

A subgroup of cases of suppuration of the lung, classified as nontuberculous infections, is fully described in the literature. The cases

6. Conner, H. M.: Personal communication.
7. Hedblom, C. A.: Personal communication.

that have been observed in the Section on Diseases of the Chest in the Mayo Clinic have been studied recently by Conner.[8] He has summarized the opinion of the section as follows:

The chief points in the diagnosis of nontuberculous infection of the lungs are: (1) cough for a prolonged period, either constant or with exacerbations; (2) little depreciation of general health; (3) little if any fever, and, if present,

Fig. 11.—Position of drainage tubes.

intermittent; (4) lack of progression of the disease; (5) location of the lesion usually in the base of the lung, and (6) absence of bacilli of tuberculosis in the sputum.

Nontuberculous infection of the lungs may be distinguished from tuberculous infection mainly by the location of the lesion in the base, by the less marked or absent depreciation in health, by lack of progression, and by the absence of bacilli of tuberculosis. Often there is leukocytosis. In at least nine of ten

8. Conner, H. M.: Nontuberculous Infection of the Lungs, Minn. Med. **5**:364 (June) 1922.

cases of tuberculosis, the infection is found in the upper lobes or apices, while almost the reverse is true of these cases. Recently, Rosenblatt reported that in 1,000 cases of tuberculosis, only three were primarily in the base of the lung. Seventeen of eighteen patient presenting basilar lesions admitted to the Bedford Hill Sanitarium with the diagnosis of tuberculosis were found to be nontuberculous. In this connection, it is well to remember the dictum of Brown that "abnormal physical signs at one apex should be considered as due to pulmonary tuberculosis until proved not to be; while those at the base should be looked upon as not tuberculous until definitely proved so."

Nontuberculous infection of the lungs is differentiated from simple chronic bronchitis by the fact that chronic bronchitis is usually generalized, is often secondary to cardiac or other disease, has less tendency to the production of purulent sputum, usually does not cause exacerbation of symptoms with increased temperature, and usually produces no leukocytosis. Moreover, in simple bronchitis, the râles are predominantly dry, while in this condition they are predominantly moist.

Bronchiectasis may usually be distinguished from nontuberculous infection of the lungs by clubbed fingers and more abundant foul sputum brought up by paroxysms of cough. Cough and expectoration are usually markedly affected by changes of position, such as lying and stooping. The cough in bronchiectasis is typically loose and a copious amount of the sputum can usually be produced by inversion. On standing, the sputum often separates into three layers. There is usually no leukocytosis in bronchiectasis.

Bronchopneumonia is usually bilateral, acute, and not recurrent, while this condition is chronic, often unilateral and recurrent. In bronchopneumonia, there are usually some signs of consolidation, while in this condition such evidence is usually absent.

In adults, the prognosis must be very guarded, as it is likely that the condition will persist or recur. It seems quite probable that most of these patients will develop a true bronchiectasis if the infection persists. In children, the prognosis is somewhat better, according to most authors, although I have not had much experience with such cases.

CONCLUSIONS

1. Nontuberculous infection of the lung is a nonspecific disease, which, however, deserves a name as a separate disease entity.
2. The essential features are cough, marked chronicity, exacerbations, little or no fever, and few other constitutional symptoms, usually purulent expectoration, lack of progression and location of the lesion almost always in the bases.
3. The principal physical sign is moist râles.
4. Diagnosis is made mainly by chronicity of cough, little effect on general health, location of signs in bases, and persistent absence of bacilli of tuberculosis.
5. In the differential diagnosis, chronic bronchitis, tuberculosis, frank bronchiectasis and bronchopneumonia must be considered.
6. Prognosis must be guarded in adults.
7. Treatment is mainly by posture.

SUMMARY

Abscess of the lung resulting from pneumonia represents the result of the patient's failure to react effectively. It is the consequence of death of tissue, and, instead of subsequent fibrosis, necrosis is the pathologic picture.

Abscess may so simulate encysted empyema with bronchial fistula as to be indistinguishable. In fact, it may be true that certain abscesses not postsurgical, may be of such a character. This is the opinion of Ashhurst,[9] and it certainly may be true in conditions which were preceded by an influenzal infection. Again, abscess may constitute the primary disease in empyema. Moschcowitz [10] is of this opinion, and Robinson [11] believes, that encapsulated forms of empyema are caused by the subpleural abscess. I have recently seen a patient whose empyema was almost certainly primary, and a small abscess in the lung secondary. This seemed so because of the histologic picture presented by the tissue around the abscess.

In many instances, the presence of empyema or of thickened pleura has made a diagnosis of abscess very difficult. Often in cases of long standing, even after operation, it has been impossible to distinguish abscess from empyema with bronchial fistula or from bronchiectasis. Only necropsy has shown the internist's and the surgeon's errors.

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9. Ashhurst, A. P. C.: Surgical Experiences with Encapsulated Empyema and Abscess of the Lung: A Plea for Exploratory Thoracotomy, Internat. Clin. 4:173-210, 1916.

10. Moschcowitz, A. V.: Newer Conceptions of the Pathogenesis and Treatment of Empyema, Am. J. M. Sc. **159**:669-701 (May) 1920.

11. Robinson, S., quoted by Norris and Landis, Footnote 5.

FIBROSIS OF THE LUNG FOLLOWING LIGATION OF THE PULMONARY ARTERY

COMBINED WITH PHRENICOTOMY AND WITH PARTIAL OCCLUSION OF THE PULMONARY VEINS *

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For the treatment of unilateral tuberculosis of the lung, two methods are now widely used, artificial pneumothorax and extrapleural thoracoplasty. These methods produce good results after a very long time, one year or perhaps several years usually being necessary to effect a cure. Special care has to be taken to improve the general condition of the patients, perhaps by residence in a sanatorium. The patients are unable to work during this period; hence, it is of great economic and social importance to shorten the time necessary to restore them to health.

Artificial pneumothorax and extrapleural thoracoplasty act indirectly. The lung is compressed from the outside, either by introducing a gas or a mass of fat or paraffin between the lung and the bony chest wall, or by bringing the chest wall into a state of collapse, as in extrapleural thoracoplasty. The second method has the disadvantage of causing an increasing deformity of the whole thorax, especially of the vertebral column. Both methods force the lung to decrease its physiologic action, the aeration of the venous blood brought in through the pulmonary artery being diminished. Hence, the circulation is altered. Stasis takes place, followed by extravasation of serum and blood corpuscles into the alveoli and the interstitial tissue of the lung. Secondary fibrosis occurs, with a tendency to shrinkage, as in all new fibrous tissue. The toxins of the foci of infection also are a strong stimulus to the formation of fibrous tissue. The two agents help each other in the endeavor to combat an infection.

A more efficacious therapeutic procedure is one which has a direct influence on the physiologic work of the lung, and which gives the diseased organ a rest, in order that it may be able to conquer a tuberculous infection. Such a procedure is found in ligation of the pulmonary artery of one lung or of one lobe. No venous blood comes to the alveoli of the compressed area. The arterialized blood in the pulmonary veins no longer is benefited by the impulse from the artery. The bronchial arteries, arising from the aorta or from the intercostal arteries, guarantee a sufficient supply of blood to the lung. Their

* Preliminary report of experiments carried on during the winter of 1921-1922 in the Surgical Hunterian Laboratory of the Johns Hopkins University Medical Department.

* Read before the American Association for Thoracic Surgery, Washington, D. C., April 29, 1922.

communication with the pulmonary veins is essential to prevent sudden hemorrhagic infarct. A considerable stasis takes place, particularly on the alveolar side of the pulmonary veins, with resultant extravasation of serum, but also with extravasation of erythrocytes and leukocytes into the alveoli and the interstitial tissue. An increase in the flow of lymph occurs at the beginning, in an effort to prevent this process; but the stasis becomes more and more effective. The suction effect of the blood from the left atrium, and the action of the thoracic wall and of the diaphragm maintain the circulation. By paralyzing the diaphragm or cutting the intercostal nerves, or by a secondary extrapleural thoracoplasty, we can reinforce the effect of a primary ligation of the pulmonary artery. Wherever a chronic stasis is present in an organ, the edematous tissue mixed with extravasated blood is gradually replaced by fibrous tissue. This is especially true when the general condition of the body is not greatly affected and the stasis is not the result of general marasmus.

It is evident, then, that a lung becomes fibrous after ligation of the pulmonary artery. The edema acts as an irritant. A superimposed infection with formation of exotoxins increases this tendency: a fact which is of great importance in the treatment of chronic infectious diseases of the lung, especially tuberculosis. By ligating the pulmonary artery, we get a firm fibrosis of the lung in a probably shorter time than in artificial pneumothorax or in extrapleural thoracoplasty. The experiments of Bruns, Sauerbruch, Robinson, Willy Meyer and Kawamura have demonstrated this fact, and clinical application of the principle in a few cases by Sauerbruch, Küttner and Willy Meyer prove that it is suitable also in cases of tuberculosis. In experiments on rabbits, I obtained the same results. A series of dogs is still under observation. The roentgenograms taken at different intervals reveal a marked increasing fibrosis. Phrenicotomy performed at the same time as ligation of the pulmonary artery is very helpful.

From my present findings, I believe that, by combining these two procedures, and by using the paralyzed diaphragm and the mediastinum as relative movable organs for the retracting lung, we shall obtain the greatest amount of fibrosis; and we shall be able to bring about healing clinically, even in very advanced cases of unilateral tuberculosis by encircling the foci of infection with a covering of dense fibrous tissue. Hence, the lung will also be prepared in a very careful way for a secondary lobectomy; and the patient will be able to recover after the first operation (ligation of the pulmonary artery), and endure much more easily a second lobectomy, which eliminates the tuberculous foci of infection, rendered quiescent by their fibrous envelop.

A second method of producing fibrosis of the lung by direct action is partial occlusion of the veins. Basing their opinion on the pathologic

findings, Rokitansky and Tripier pointed out that an organic heart lesion diminishes the tendency to tuberculosis of the lung. Eichhorst and Fraentzel restricted the application of this law, basing their opinion on their clinical experience in lesions of the left side of the heart. Tiegel proved experimentally the truth of the law that partial occlusion of the pulmonary veins of one side or of one lobe, followed later by intravenous injection of tubercle bacilli, makes the side or lobe of the lung so treated much less liable to infection than the side on which operation was not performed. By this operative procedure also, we secure stasis in the lung, with resultant edema and extravasation of blood. The inflow from the pulmonary artery meets an obstacle, which persists. The resulting edema has, within a few months, the same effect on the lung as ligation of the pulmonary artery. Fibrosis takes place, with a tendency to be most dense around the foci of infection, the toxins acting as increasingly powerful stimuli to this fibrous tissue formation. A series of dogs on which I made this occlusion are still under observation.

In patients having a slight infection on one side, with a family history of several cases, this procedure, carried out with a Halsted metal band, may be the procedure of choice. The stasis must be effective for at least several months. After taking off the band, later, the function of the lung could be partly restored. The effect of this procedure in a lung threatened by infection, when the organism shows diminished resistance, would be partly curative, partly preventive.

A third method of bringing a lung to functional rest would be blocking the air passage. This was done experimentally by Dr. Halsted, and then by Dr. Crowe at the Johns Hopkins University, who blocked the main bronchus of a lung with a piece of fascia. After a few months, a dense fibrosis of the resting lung had developed. The lung became much smaller. The bronchi were considerably enlarged, proportional to their size, and were filled with a homogeneous, jelly-like mass.

These are the three different procedures which cause fibrosis of the lung in the same way, by direct decrease in the physiologic function of the lung. Immobilization of the organ hastens the process. The results may be obtained in a relatively short time, probably shorter than by using the indirect methods of artificial pneumothorax and extrapleural thoracoplasty. Ligation of the pulmonary artery combined with phrenicotomy, or partial occlusion of the pulmonary veins, are methods which should be worked out clinically for cases of unilateral tuberculosis. The findings in the experiments, and a few clinical observations, encourage us to follow up this aid to thoracic surgery for the cure of patients suffering from chronic infectious disease of the lung, particularly tuberculosis of the lung.

OBSERVATIONS ON LUNG SUPPURATION AND ITS TREATMENT

A BRIEF REVIEW OF PERSONAL EXPERIENCES AND CLINICAL IMPRESSIONS OBTAINED WITHIN THE LAST TWELVE YEARS *

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The principal topics dealt with in this paper are:

I. The nomenclature of lung suppuration.
II. The results obtained with the help of the bronchoscope in the treatment of lung suppuration.
III. The establishment of a lung lip-fistula in certain cases of bronchiectatic lung abscess.

ETIOLOGY

The etiology of suppurative inflammation of the lung is similar to that of pus formation in other parts of the body. That is to say, it is due to traumatism inclusive of the entrance of a foreign body; to the invasion of the pulmonary tissue by pus-forming microbes, the products of which are not absorbed, but form an abscess; to a specific inflammation of the chronic type (tuberculosis, syphilis), or, lastly, to the presence of, or the breaking down of, a benign or malignant tumor.

Fulminant, acute inflammation, subsequent to the sudden occlusion of a large branch of the pulmonary artery by a virulently infected embolus or to the aspiration of extremely septic material, which is likely to produce acute progressive gangrene and pus formation, also exceptional conditions, as actinomycosis and suppurating hydatid, are not considered here.

If, in the term "foreign body," we include also liquids, or in other words, if we substitute the word "substance" for "body," we may be right in asserting that the great majority of pulmonary suppurations, excepting, of course, tuberculosis and syphilis, are due to the entrance of a "foreign substance" into the bronchial tree and lung tissue. The bullet, pieces of clothing, bone-splinters, etc., that enter the organ in violent traumatism from without, through the chest wall, as well as "foreign substances" that enter the bronchial tree and lung tissue by aspiration through the mouth and the trachea, all tend to produce inflammation and suppuration.

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After some time has elapsed, the suppuration invariably involves the alveolar tissue of the lung, plus the communicating bronchi, the two structures within the lung which always represent a unit in a pathologic sense.

The degree and rapidity of inflammation depend on the virulence of the bacteria that enter with the foreign substance, that is to say, on the infectiousness of the material. Of aspirated fluids, the principal representatives, according to clinical experience, are: (1) stomach contents, aspirated during general anesthesia, stomach lavage, etc.; (2) blood and mucus, mixed with semisolid or solid infectious material (plugs, tissue), aspirated in the course of nasopharyngeal operations, particularly tonsillectomy, or the removal of adenoids, and (3) infected water, aspirated while the person is swimming.

It is also possible, and appears plausible, that the sputum, discharged from the alveoli during the course of the inflammation and the convalescence from typical pneumonia, is reaspirated from the bronchial tree with the paroxysmal deep inspirations following the coughing spells, and produces a postpneumonic lung suppuration. Such sputum may also be aspirated into hitherto uninfected parts of the lung in the act of expectoration and subsequent inspiration.

In other instances, the pneumococci, or a microbic infection of a different type (streptococci, or other pyogenic bacteria), may directly produce a suppuration of the lung in the presence of nonresolution of the inflamed area.

It is different with tuberculosis and syphilis, in which one or more tubercles or gummas break down, producing suppuration. And even there, it appears plausible to assume that the "spread" of the purulent inflammation is often due to aspiration, producing a slow or quick sequence of lobular pneumonic foci.

The aspiration of pus and mucus from an abscess of the upper portion of the lung into other parts of the organ, particularly into the lower lobe, for example, during an extrapleural thoracoplasty in an operation for advanced pulmonary tuberculosis, or in an operation for nonspecific chronic suppurating disease of the lung, although belonging to this class, has a place of its own.

I believe that the dreaded lung suppurations following tonsillectomy and the removal of adenoids are almost all due to aspiration of blood, mucus, particles of the infected glandular tissue or tonsillar plugs during the operation. The theory of lung infection subsequent to tonsillectomy by way of the blood stream seems far fetched and less plausible, although one or the other case may perhaps develop in this way.

GROSS PATHOLOGY AND NOMENCLATURE

In the evolution of the subject of subacute and chronic lung suppuration, the discussion centers around typical subacute and chronic

lung abscess on the one side, and bronchiectasis on the other. The border line between the two conditions cannot be sharply drawn. Where does the pathologic picture of lung abscess end and that of bronchiectasis begin? It is hazardous for one not a pathologist to plunge into that question.

There is, at present, a great deal of confusion in the nomenclature of lung suppuration. Without entering into the details of the well known gross pathology of these affections, I should venture to say, from a clinical standpoint, that the "single" circumscribed cavity within the lung, that contains pus and nothing else, should be regarded as lung abscess, whereas a "multilocular" cavity formation with suppuration, which, on cross section, presents a honeycomb-like appearance, a purulent disease of chronic character, which had spontaneously attacked many places within one or more lobes of the lung, on one or both sides of the chest, before the patient had surgical or special treatment, represents bronchiectasis.

Of course, I realize that a true lung abscess can occur in multiple affections, for example, one single circumscribed cavity may occur in the upper and one in the lower lobe of the lung, just as we may find one abscess cavity in the left lobe of the liver and a second one in the right lobe.

Between the two classes are transitions which are seemingly difficult to classify. I have opened an abscess in the depth of the lung, in which, when palpating, the finger passed "around the corner"—the corner being formed by a projecting, partially broken down portion of the wall of the bronchus at its subdivision—and entered into a second smaller pus cavity. Both contained fibrinous coagulations with detritus of very foul odor. This is not a typical abscess, nor is it bronchiectasis. To my mind, it seems correct, clinically, to call such a cavity a "bronchiectatic lung abscess," that is, an irregular cavity, which evidently is the result of a local gangrenous inflammation of the lung, due either to aspiration and its consequences, or I believe, in rare cases, in which the history disproves aspiration as well as the breaking down of a gumma or of a tumor, to an infectious embolism of small caliber and low virulence. The cavity usually contains, as just stated, many round and irregularly shaped, very soft and friable masses, fibrinous coagulations of varying size, usually not larger than a marble, plus grumous material, all of which have the same fetid odor as the sputum. Microscopically, these coagulations show necrotic tissue, blood clots and fibrin, containing many polymorphonuclear leukocytes and clumps of bacteria.

Clinically, I would then divide subacute and chronic nonspecific lung suppuration not due to traumatism nor to exceptional occurrences, such as actinomycosis, into three classes:

1. *The Typical Lung Abscess.*—This occurs usually subsequent to an attack of influenza or pneumonia; that means it is, in other words, an ordinary abscess, due to the breaking down of the tissue of the lung, which is attacked by the inflammation, and it has a tendency to heal after surgical evacuation.

2. *Typical Bronchiectasis.*—This is the multilocular cavity formation within one or more lobes of the lung—in exceptional cases, in both lungs—which, on section, presents a honeycomb-like suppurating appearance.

3. *Bronchiectatic Lung Abscess:*

In the typical bronchiectasis, the anatomic structure of the bronchial tree is primarily affected; but naturally the surrounding lung tissue is also involved later on, the intensity depending on the extent to which a mixed infection with its deleterious results has invaded these cavities.

The more I have thought about this affection and seen it, the more I believe that it must be of congenital origin, at least in the greatest number of cases. We should best reserve the term bronchiectasis for this particular, typical lung affection. It will always be easily recognized as such pathologically, after one has once seen the remarkable specimen after removal, either at operation or necropsy (Fig. 1). Clinically, it is found mostly in young persons who have had neither pneumonia nor influenza or submitted to any nasopharyngeal or other operation under general anesthesia. It affects more often the lower lobe than the upper, and is found more frequently on the left than on the right side. The secretion of these abscess cavities may not necessarily be foul. Lately I have observed a young man, aged 17, who has been sick for more than two years. When asked to expectorate, he could fill, in the exaggerated knee-elbow posture, quickly and at will, more than half of a medium-sized pus basin. The secretion poured from his nose and mouth as in a vomiting spell, and it had no odor whatsoever. On examination of the same patient during operation, the surface of the lung was of the normal, yellowish-pink color. The presence of a pathologic condition was demonstrated only by a greater resistance to the examining finger. The pulmonal pleura was entirely normal and without adhesions.

The third class, the so-called "bronchiectatic lung abscess," should embrace all the other nonspecific and nontraumatic subacute and chronic lung suppurations which are so frequently found. The term well describes the pathologic picture seen after opening and evacuating the abscess. The observer perceives large and small open cavities, which communicate with the visible central defect, the former bronchiectatic abscess. When its contents are removed, any portion of the interior of the cavity, under good illumination, shows a picture not unlike that of the dilated pelvis of a kidney after removal of pus result-

ing from a pyonephrosis. If we take a plaster cast of a bunch of grapes of varying sizes, divide the cast lengthwise and remove the grapes, the cavity of such a half, "the negative," resembles to my mind the appearance of the cavity of what we have called "bronchiectatic lung abscess." Of course, we must imagine that in many places, and scattered throughout the inside, the cut surfaces of larger and smaller bronchi would appear.

Fig. 1. (Case 17).—Lower lobe of the left lung of a boy, aged 6, with typical bronchiectasis; specimen divided longitudinally.

In some of these cases, more than one cavity may be present, which cavities naturally communicate with, and empty their secretions through, that branch of the main bronchus through which aspiration took place, or which belongs to the area infected by a septic embolus. The second cavity may communicate with the first by a larger bronchus tract, and then drain to the surface sufficiently to heal (Case 2); or it may communicate with the first by means of a small bronchus, thus representing

a typical "hour-glass shaped" bronchiectatic abscess cavity. If the second also contains fibrinous coagulations, it will keep up the clinical symptoms of improperly drained lung suppuration and require special incision with drainage (Case 5).

The chosen nomenclature, bronchiectatic lung abscess, might be criticized, and perhaps rightly so. Etiologically, pathologically and clinically, this affection represents something different from typical bronchiectasis. There are no multiple cavernous distentions of the bronchial tree, with inflammatory affection and breaking down of the surrounding lung tissue. There is a total defect of bronchi, plus adjacent lung tissue, a larger cavity, the result of gangrene and expectoration of broken down lung tissue, which was healthy and normal before the inflammation had set in. The term nonprogressive local gangrene of the lung would cover the pathologic picture. However, it seems better, in order to keep in line with the accepted nomenclature of suppurative chronic lung disease, to call such a cavity a "bronchiectatic lung abscess," as long as we know and remember what the name implies.

DIAGNOSIS

Clinical and laboratory examinations, roentgenography and bronchoscopy combine to establish a more definite diagnosis. The typical lung abscess often shows the classical symptoms of cavity formation in the lung. On percussion, dulness is elicited if the abscess is in the depth and surrounded by infiltrated lung tissue; if nearer the surface, the sound is tympanitic (the positive coin sound, and the cracked pot sound when the patient opens the mouth). On auscultation, loud bronchial breathing is heard, with a difference in the voice sound, loud and whispered, and larger and smaller râles. The history, the short duration of the disease, elastic fibers in the purulent sputum, which is not very copious and which usually has a sweetish odor rather than the terribly foul odor often encountered make one suspect the presence of abscess.

The clinical findings may be trivial on percussion and auscultation in typical bronchiectasis. But the long existence of the trouble, often extending from childhood or adolescence; the copious twenty-four hour sputum, which, in rare cases, is odorless, although usually it possesses a terribly foul odor and at times is intermingled with bloody streaks, and does not contain elastic fibers, a sputum that shows three layers on standing, and, if involving the right middle or one of the lower lobes, frequently pours out of the mouth and nostrils in immense quantities when the patient places himself in a pronounced knee-elbow posture; the clubbed terminal phalanges of the fingers and toes should make the diagnostician consider this disease.

The diagnosis of bronchiectatic lung abscess requires, besides the classical clinical symptoms of a cavity, or cavities, a history of aspiration

or of sudden onset of the trouble at any time of the patient's life without traceable cause. The sputum is also copious and always very foul.

Stereoscopic roentgenograms present a beautiful plastic picture of diffuse density, but often fail to assist the surgeon in making the diagnosis of typical bronchiectasis. They are, however, of much value in cases of the typical lung abscess, as well as of the bronchiectatic lung abscess. Here they often demonstrate clearly the presence of one, or more, larger or smaller cavities, with a distinct fluid level.

Much remains to be done, it seems to me, by roentgenologists in this type of disease. They must learn, not only to determine the presence of an abscess, but also to localize more accurately the focus, and, if possible, the exact location of adhesions between the pulmonal and costal pleura. True, now and then they succeed in localizing correctly the seat of the trouble, telling us how many inches we have to measure from the spinous process of the seventh neck vertebra down, and how many from there to the right or left side, in order to find the spot where the aspirating needle should enter and strike the abscess. But these cases, up to date, are exceptions; and we are not advised so far at what depth we are likely to enter the cavity, how many inches below the surface of the thorax we may expect to find it.

It is to be hoped, and greatly to be desired, that roentgenologists will devote further thought and investigation to this subject, in order to give the surgeon the real assistance which he needs when proceeding with his operative work on conservative lines.[1]

If the surgeon is bent on lobectomy, a refined diagnosis is, of course, superfluous. All he might find it convenient to know before operation is whether one or more lobes are the source of the sputum.

Comparing at present the value of roentgenographic and specialistic assistance in establishing the accurate diagnosis of lung suppuration, a trained bronchoscopist certainly is the best friend of the surgeon. He will clearly localize the disease and indicate definitely which lobe is the only, or principal, source of the sputum. If a bronchoscopist is not available, or if the operator does not favor such specialistic examination, direct inspection and palpation of the lung after thoracotomy will give

1. A few days ago I received a communication from the roentgenologist of the Lenox Hill Hospital, Dr. William H. Stewart, in which he recommends that "in order to make accurate localizations, the roentgen examination should be made fluoroscopically in the operating room, the patient being placed in a position similar to that in which he is placed by the surgeon for the operation. Roentgenologists now have a small Coolidge tube which is immersed in oil in such a way that all of the high tension wires are protected so that danger from shock to the operating room force is eliminated. The fluoroscopy is done by the roentgenologist in the operating room, with the aid of a hooded

(Continued on page 368)

the experienced surgeon the desired information regarding the actual extent of the disease. Still in determining whether radical or a more conservative operative interference is indicated, it is of very great value to know beforehand the exact location and extent of the disease.

PROPHYLAXIS

1. *Aspiration of Stomach Contents During and After Operation, also During Gastric Lavage.*—Careful preparation of the patient for operation, trained anesthetists in attendance at the operating table, and watchfulness *after* the patient has been returned to his bed, combined with proper posture (Sims'), more important still, gradual widening of the field of regional and local anesthesia in our daily operative work, will help to reduce the number of lung affections due to aspiration during and after the operation. Sims' posture in horizontal or in a slight Trendelenburg position will prevent aspiration of mouth secretions and vomited material while the patient is being returned from the operating table to his bed, as well as later, also during gastric lavage.

2. *Aspiration During Nasopharyngeal Operations.* — Instrumental evacuation of fluids from the mouth and throat by continuous suction, with proper posture of the patient during tonsillectomy and adenoidectomy, better still, operation performed under local anesthesia whenever possible, with crushing of the blood vessels before division, at least in older children and in adults, will enable the specialist to prevent, or reduce to a minimum, aspiration of infectious material below the glottis in the course of his work.

If the operator prefers general anesthesia—and he may be justified in this because a number of deaths, seemingly directly due to local anesthesia in cases of tonsillectomy, have of late been reported—a trained anesthetist is the principal factor in avoiding lung complications. Certainly, this most important subject of performing tonsillectomies and nasopharyngeal operations under local or general anesthesia is in great need of further unbiased discussion.

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fluoroscope, through which he can clearly see the course of the needle and thus aid the surgeon in locating the abscess cavity. I quite agree with you that one cannot depend on this method alone, and that preliminary localization should be made prior to the fluoroscopy in the operating room at the time of the operation. Difficulty in making accurate preliminary localizations is largely due to the following: (1) neglect on the part of the roentgenologist properly to center the roentgen-ray tube through the diseased area; (2) considerable change in the localization during inspiration and expiration; (3) examination of the patient most frequently in positions which do not correspond to those used by the surgeon on the operating table; (4) relaxation of the patient when fully anesthetized and on the operating table, which has a tendency to change conditions to some extent from those which existed at the time of the preliminary localization."

3. *Aspiration of Infected Water While Swimming.*—Lung abscess due to aspiration of infected water is a rare occurrence. However, a few true cases have been observed by the late Dr. Lynah of New York City in two boys who had gone for a swin in the infected waters surrounding Manhattan Island. One of them almost drowned. In every case, the colon bacillus was found in pure culture in the lung abscess.

This observation affords important hints as to how to avoid such occurrences in the future, and how eventually to prevent a full development of the late results of such aspiration. In order to prevent such occurrences absolutely, it is necessary to give New York and other cities similarly situated a proper drainage system conforming to the rules of modern advanced sanitation, and stop draining directly into the rivers surrounding our large cities. That, however, is for the present moment a "pium desiderium."

With regard to forestalling the full development of lung suppuration due to aspiration in general, by means of preventive therapy, it seems to me that experience with the bronchoscope already at hand clearly points to the necessity of a quick, aggressive plan of treatment. Knowing that the late result of any type of an aspirated foreign substance into the lung means almost always suppuration of the lung, the primary duty of the physician and the surgeon is clearly outlined. The foreign substance which has entered the bronchial system, be it solid, semisolid or liquid, ought to be removed as soon as possible, before it has time to get a firm hold on the lung tissue itself. Judging from the remarkably beneficial result of bronchoscopic suction in an early case of mine, and a few additional similar ones seen by others, I incline to the hope that prompt cleansing of the stem bronchi and their respective divisions, which may clinically mean cleansing also the adjacent lung tissue itself, by means of aspiration in the hands of an expert, irrespective of the presence of high fever and general malaise, will prove a most valuable prophylactic means in avoiding, or at least mitigating, the threatening acute, subacute and chronic lung suppuration in some of these patients.

Who can tell but that perhaps in the future the medical man will join hands with the bronchoscopist, even in the treatment of pneumonia proper, not alone of the aspirating type, when it comes to particularly difficult, long drawn-out cases! How clearly, then, it is the duty of every modern hospital to have on its staff an expert bronchoscopist.

TREATMENT

In the beginning of our thoracic work, the indication as to whether and how to proceed could not be correctly established. We were actually groping in the dark. With the personal willingness to help

these patients by operation, and not always knowing which method, conservative or radical, would be best adapted to the case in hand, also trying to help in developing the various operative procedures, I feel today, on looking back, that several patients were operated on to whom it would have been better to refuse operation, and that some patients were submitted to a definite surgical interference in whom another procedure might have given better results.

Before glancing over the practical results that have been obtained and observed by me within the last twelve years by the various methods of surgical treatment, specialistic and operative, in acute, subacute and chronic nonspecific lung suppuration, a brief statement appears proper as to how it came about that I have tested "all" the conservative methods of dealing with the disease in question, besides, of course, treating several patients also with resection of the lung.

In our experimental work at the Rockefeller Institute, in the years 1908 to 1912, we had found that healthy dogs stood the removal of one or more lobes of the lung very nicely. They were almost entirely well after forty-eight hours, jumping around and barking as if nothing had happened: another proof of Nature's wonderful generosity in endowing the animal (human) system.

Of twenty-six dogs thus operated on, twenty-two recovered (84.6 per cent.).[2] When testing the contents of the chest, in the place of the removed lung lobe or lobes, the aspirator invariably found air, never fluid, in contrast to the experience of Sauerbruch and Robinson, who always found fluid.[3]

I believe, with a perfectly aseptic course of healing after lobectomy in the healthy dog, with separate ligation of the blood vessels that accompany the bronchus, also with crushing, combined with air-tight inversion and suture of the bronchial stump and subsequent immediate complete closure of the chest, air will be found as a rule within the chest in place of the excised lung portion, and not serous fluid.[4]

The anatomic proof of how Nature then takes care of the resulting defect was rendered possible through the courtesy of Dr. Francis Carter Wood of New York, who was good enough to give us his active assistance in this part of the work. At various intervals after the operation, under general anesthesia, he bled to death the dogs thus operated on, through an incision into the femoral artery, and then injected a 5 per cent. aqueous dilution of liquor formaldehydi into the vascular system. Thereupon, the cadaver was frozen and the thorax

2. Meyer, Willy: Zentralbl. f. Chir. **36**:1713 (Dec.) 1909.
3. Sauerbruch and Robinson: Deutsch. Ztschr. f. Chir. **102**:542, 1909.
4. Heuer, G. J., and Dunn, G. R.: Bull. Johns Hopkins Hosp. **31**:31 (Feb.) 1920.

cut horizontally with a saw, at different levels. The specimens thus obtained were most instructive. They proved, anatomically, what had long been observed clinically in patients with diseased portions of the lung; namely, that the opposite mate hypertrophies, and, through distention of its parenchyma (compensating emphysema), gradually fills the place of the cavity produced by the excision of the lobe. Some of these specimens were shown at the meeting of the American Surgical Association in Washington, 1912.[5] They are still in my possession.

With this experience in mind, May 12, 1909, we approached rather enthusiastically our first attempt at lobectomy in the human being. The patient, a boy, aged 6 years, with typical localized advanced, evidently congenital, bronchiectasis of the left lower lobe, had been referred to me by the late Dr. Pisek of the Post-Graduate Hospital. With the patient's head and the anesthetist under differential pressure within the positive pressure cabinet—the only type of apparatus for differential pressure then available with the exception of the negative chamber, which had not yet been installed at our hospital—we opened the chest, loosened the adherent lobe and treated the pedicle, bronchus and blood vessels, as we had learned to do in our experimental work. Today, we know that such detailed treatment of the chronically inflamed stump is not advisable in human beings. After the vessels had been ligated, we crushed the bronchus with a powerful clamp, and, just as we were tying it, the anesthetist informed us that the patient had suddenly stopped breathing. Long-continued efforts at resuscitation failed. We were all utterly disappointed and unhappy and tried to explain our experience in various ways: acute dilatation of the right heart, owing to the continuous increased air-pressure in the presence of a heart muscle, weak and diseased from years of septic infection, vagus reflex, etc.

This experience occurred a few weeks before the arrival of Dr. Friedrich, then Professor of Surgery at the University of Marburg, Germany, who had come to America in the spring of 1909, at the invitation of the American Medical Association and the American Surgical Association to attend their annual meetings. When I discussed the boy's death with him, he gave me the following advice: "Do not attempt to excise every chronically suppurating bronchiectatic lung lobe in the human. Lobectomy is still a very serious operation, and thoracic surgery is still a very young child. The many deaths that would most likely result might give thoracic surgery a black eye in the estimation of our medical brethren. Rather go ahead slowly and cautiously, and try conservative methods first." I took his advice, and, in the course of the subsequent years, conscientiously and faithfully

5. Tr. Am. Surg. A., 1910, p. 242.

tested, step by step, all the various conservative operations advised for the surgical treatment of nonspecific pulmonary suppuration: (1) collapse of the lung in the absence of adhesions by means of gas or air (artificial pneumothorax); (2) operative collapse of the lung, in the presence of adhesions between pulmonary and costal pleura, by means of a thoracic incision and intrapleural loosening, with division of these adhesions, and closure of the chest with the lung collapsed; (3) operative collapse of the lung, in the presence of adhesions between pulmonary and costal pleura, by means of extrapleural thoracoplasty (multiple rib resection); (4) ligation of a branch of the pulmonary artery, with or without thoracoplasty; (5) resection of the lung; (6) incision of the lung with drainage; (7) bronchoscopic treatment in the hands of an expert.[6]

A bird's eye view of the surgical treatment of suppurative inflammation of the lung permits one to place it parallel with that of suppurative inflammation of the kidney. In acute and chronic pyelitis, we perform cystoscopy and ureteral catheterization with antibacterial irrigation of the renal pelvis; in suppurating pyelonephritis, particularly when due to stone, we employ incision plus drainage, and, in advanced cases, after proper functional tests, nephrectomy. What cystoscopy and ureteral catheterization, inclusive of the use of the operating cystoscope, accomplish in renal surgery, bronchoscopy (peroral endoscopy) does in the early and later treatment of certain suppurative pulmonary processes; nephrotomy corresponding to pneumotomy and nephrectomy to lobectomy.

Let me now briefly survey what I have seen and learned in this class of cases in the last twelve years. I shall do so under the three headings discussed above, namely, lung abscess, bronchiectasis and bronchiectatic lung abscess.

A. LUNG ABSCESS

These abscesses usually are, as mentioned above, the sequelae of an attack of pneumonia or influenza; possibly some cases are also due to an embolism of an infected thrombus of small caliber and low degree of infection, or to the entrance of bacteria as emboli, by way of the blood stream.

In dealing with the treatment of this disease it must be borne in mind that such a lung abscess may heal spontaneously, as may be seen from the following illustrative case:

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6. I did not try the transposition of the affected lobe according to Garrè, nor the subdiaphragmatic transposition of the diseased lower lobe, in combination with, and rendered possible by, artificial paralysis of the diaphragm on the same side by means of phrenicotomy, as proposed by Henschen.

CASE 1.—Several years ago, a man with a typical unilocular, suppurative lung disease was seen by me in consultation and admitted to the hospital. General and local treatment (posture expectoration, Priessnitz dressings, good nourishment, etc.) was instituted. Slow improvement followed. A localized cavity, well manifested clinically, persisted. Operation was advised, but not accepted. After several weeks of observation, the patient left the hospital and was lost sight of. Later, by chance (discussion at a medical meeting), definite news regarding the patient's condition was received from his attending physician to the effect that the man had completely recovered without operation.

Similar cases are reported in the literature. The operations for lung abscess which I have performed during the last twelve years are the following:

CASE 2.—M. W., a man, aged 41, who had been sick for ten weeks, and who expectorated quantities of pus, had an abscess in the left lower lobe, following pneumonia. The roentgen-ray findings were positive. Aspiration in the eighth intercostal space and paravertebral line detected pus. Operation was performed April 19, 1915, at the Lenox Hill Hospital, under local anesthesia. The eighth and ninth ribs were resected posteriorly, and the intercostal tissues excised. Aspiration in the bed of the ninth rib again detected pus. A large cavity was opened with the Paquelin cautery alongside the needle. Many bronchi communicated with the abscess cavity. Tamponade was followed by cure.

CASE 3.—A. L., a man, aged 32, had had influenza four months previously. Since then he had had a cough and purulent intermittent fetid expectoration, of moderate quantity in twenty-four hours. On standing, it formed three layers. The roentgenograph and bronchoscope corroborated the clinical diagnosis of localization in the left lower lobe. The patient was the father of a big family. He consented to operation, but demanded the mildest interference. Jan. 11, 1917, operation was performed under pharyngeal anesthesia. Through an incision in the seventh intercostal space down to the pleura, the lung was seen to move. The pleura was opened; and the lung was perfectly free anteriorly, and, laterally, it was adherent only near the spine, in a larger area, from the level of the incision upward. Pneumotomy was decided on. Aspiration in the paravertebral line, near the posterior wound angle, a needle still entering within the area of incision, revealed pus, from about 1½ to 2 inches below the surface. The needle was removed and the puncture spot compressed. Resection of the seventh and eighth ribs for their entire length with total excision of the intercostal soft tissues was performed. Air-tight drainage in the ninth intercostal space posteriorly was provided for. Layer sutures of the chest wound were inserted in the anterior three-quarters, care being taken to close the pleural cavity thoroughly. The latter procedure was difficult in front on account of tearing of the tissues. Here iodoform gauze was placed on top of the suture line, the border of a tampon being tucked under the muscle. Repeated aspiration posteriorly then did not draw pus, but the needle dropped into a cavity, from which air was easily aspirated. The focus was exposed alongside the needle, the actual cautery dividing the lung perpendicularly downward, that is, parallel with the spine. Pus and detritus were evacuated. The wound was loosely tamponed, the dressing being held in place by adhesive plaster. Air-tight drainage worked admirably. In the course of the after-treatment, suppurating pleurisy developed, with marked febrile symptoms. The varying kinds of pleural discharge could be observed beautifully through the glass tube,

which was interposed in the rubber drainage tube leading from the chest to the syphon below. However, the inflammatory attack was easily overcome by this method of after-treatment. Then followed uninterrupted recovery (Fig. 2).

CASE 4.—H. B., a man, aged 24, the clinical diagnosis of whose case was abscess in the right lower lobe, corroborated by roentgenography, when examined bronchoscopically showed discharge from one branch of the lower lobe only, proving localization of purulent inflammation. Aspiration, with the patient in the sitting posture and in the scapular line, detected pus. Operation was performed, March 8, 1917, at the Montefiore Hospital, under general anesthesia. A curved posterior periscapular incision was made with resection of a good-sized portion of the fourth to the seventh ribs, with the intercostal tissues. Aspiration was successful through a Paquelin incision. Only a small amount of pus was evacuated. Loose tamponade and dressing were applied. The same evening, the pulse was 132, respiration 40, indicating aspiration pneumonia. The first deep dressing was made on the seventh day. The wound was in good condition. The high temperature with rapid pulse continued. March 16, the patient died. Necropsy revealed the principal abscess cavity in the lowest portion of the upper lobe, separated from the operative field by a very thin wall. Multiple lobular pneumonic foci were detected in the left (opposite) lower lobe, evidently the cause of death.

Epicrisis.—1. When only a small amount of pus is found on opening a lung abscess, a larger quantity being expected, exploratory puncture should be made from within the lung wound in various directions in the search for neighboring cavities.

2. Local anesthesia should be pushed to the limit, when operating on these patients.

CASE 5.—A man, aged 35, had an abscess in the upper portion of the left lower lobe, from no definite cause. He had been sick for five months, coughing pus, at times mixed with blood. Aspiration by a consultant outside the hospital had detected pus in the axillary line. Clinical examination, with stereoscopic roentgenography and bronchoscopy, located the cavity at about the fourth intercostal space in the axillary line. No foreign substance was seen within the bronchial tree. Operation was performed, Oct. 22, 1917, at the Lenox Hill Hospital, under local and general anesthesia, later on a general anesthetic being required. The skin incision was made over the fourth rib in the axillary line. Resection of a portion of the fourth and fifth ribs was made, then also of the third rib through the same incision. When excising a piece of the third rib, a rent was torn in the pleura above the upper border of the bone. The opening was used for exploration with the finger. The lung was found adherent in the fourth intercostal space; otherwise it was perfectly free. The pleural rent was temporarily compressed with a pad of moist gauze. Aspiration in the fourth intercostal space, within the area of adhesion, detected pus, about 2 inches deep. With the needle and syringe held in place by an assistant, air-tight drainage of the pleural cavity in the ninth intercostal space, posteriorly, was quickly carried out. Closure of the pleural rent by suture proved technically impossible; therefore, the costal pleura was stitched to the surface of the lung. At one place, a gauze tampon was required as the tissues tore. Trusting in the efficacy of the air-tight drainage of the pleural cavity, and also having had a fortunate similar experience (Case 3) in mind, the lung was incised alongside the aspirating needle

with the cautery, and the abscess emptied and drained. The lung wound was left wide open. The first three days the convalescence was favorable. The temperature was slightly higher than before operation, the pulse was good. On the fourth day, some emphysema of a mild degree appeared around the face, neck and upper extremities. It was nonprogressive. The temperature was low; pulse, full, though above 120. Arrangements were made to change the deep dressing under differential pressure, when the patient suddenly died.

Only wound inspection was permitted. A small amount of turbid fluid was found in the pleural cavity, and some air bubbles in the mediastinum.

Epicrisis.—1. Too many ribs should not be excised for opening a lung abscess, when the abscess has been definitely located. Resection of one or of two adjacent ribs, here the fourth and fifth, would likely have given the access required and the desirable yielding of the chest wall during cicatrization.

2. A rent in the pleura presents a grave complication. Particular care is required on the part of the surgeon when resecting ribs in the upper portion (from the fourth upward), where this accident is particularly liable to occur on account of the triangular shape of the ribs.

3. In case an accidental pleural rent does occur, which cannot be closed by suture, a two-stage operation is preferable, viz., immediate complete closure of the wound with air-tight drainage of the pleural cavity; incision of the abscess being performed at the second stage.

Case 6.—A woman, aged 26, who had postpneumonic lung suppuration, had been sick for many months. She had high fever, and expectorated 400 c.c. of sputum in twenty-four hours. The roentgenogram revealed clearly a cavity in the right upper lobe. The patient was admitted to the hospital, Oct. 18, 1919. Under careful nursing and hydrotherapeutics, steady general improvement occurred, as well as local improvement, as shown by gradual decrease of sputum and diminution of roentgenographic shadow. But the patient was restless and pleaded for the carrying out of treatment that promised quicker, definite results. November 20, aspiration of the lung, anteriorly and posteriorly, was performed in various places, with preparations ready for immediate operation. The result was negative, and operation was advised against. Conservative treatment was continued. There was no further rapid decrease in the cough and amount of sputum. The patient insisted on operation for various personal reasons. The surgeon's better judgment, which favored further temporizing, was overcome by humanitarian sentiments. Operation was performed December 3, with no primary aspiration. On the basis of the roentgenologist's exact measurements as to localization of the pulmonary focus, which placed it nearer the back, and after thorough preparation by means of regional and local anesthesia, a posterior hook incision was made. The scapula was loosened and pulled aside, the fifth to the seventh ribs, inclusive, being resected. The intercostal tissues were excised. The pleural leaves appeared adherent. Repeated aspiration at various levels and in different directions from the exposed area failed to reveal pus, but the syringe barrel filled quickly with air at one place, and the patient expectorated some blood. Remembering the rule that easy aspiration of air into the barrel of a faultlessly working syringe has, more or less, the same value clinically

as aspiration of pus, it was assumed that the abscess cavity had been struck, its contents having been evacuated by posture and voluntary expectoration before operation. Actual cautery division of the lung tissue was accomplished. Suddenly severe hemorrhage occurred, which did not cease when gauze tampons were gently removed after prolonged digital compression. It became necessary to stop the operation, pack the lung wound, and compress it with broad strips of adhesive plaster. After a few days of comparative well-being, a slowly rising temperature, with increased pain and cough, developed. The deep dressing was changed, the wound was perfectly dry, and there were no granulations. Some pus oozed from the lung wound. On the ninth day after operation, the patient died with symptoms of lung edema. Necropsy or wound inspection was not permitted.

Epicrisis.—1. The surgeon should not submit to the patient's wishes in the face of gradual improvement, in this class of case, which may mean spontaneous cure.

2. If pneumotomy is decided on, one should try to enter the lung from the front or the side, not from behind, even if roentgenography localizes the focus nearer the back than the front or the side. It is evident, and clinical experience proves it, that the larger sized pulmonary vessels are more easily injured by posterior approach.

COMMENT

In thoracic operations in general, as well as in the operative treatment of typical lung abscess, I consider it to be of the utmost importance and greatest benefit to the patient, if a "virgin" pleural cavity had been entered during the approach to the focus, accidentally or intentionally, or if a pleural cavity had been opened that presented but a few adhesions, to arrange the further advance in such a way that the thorax will be closed with air-tight drainage at the completion of the operation. Never, to my mind, should a gauze tampon, even if hermetically covered with a rubber dam—the latter's borders then being glued to a cover of sterile zinc ointment, spread over the skin—be left in the angle of a pleural incision or a pleural rent, if the latter tears on suture and cannot be securely closed otherwise. It seems advisable, then, to decide on a two-stage operation and close the incision completely, employing air-tight drainage of the chest, after the hand palpating within the pleural cavity has detected the situation of lung adhesion, which almost invariably corresponds to the suppurating focus beneath. A superficial cross mark with the knife should mark this important spot on the skin. This is the place where the aspirating needle must enter when the first incision has firmly healed.

If conditions permit incision and drainage of the abscess at the same sitting, it naturally affords an advantage for the patient (Case 3). However, these have to be looked upon as representing particularly

fortunate occurrences. I feel that the patient in Case 5 would have had a better chance for recovery had I performed the operation in two stages. He died, I think, not as a result of infection caused by incision and drainage of the abscess at the same sitting, but of infection caused by the incomplete closure of the thoracic wound, producing an incomplete postoperative lung collapse, a "sucking wound," with its ever great invitation to general sepsis.

If for any reason air-tight drainage of the pleural cavity appears impossible, it would be taking chances to close the thorax and leave the patient to himself. Under such conditions, the pleural wound that cannot be closed should, to my mind, be left open, completely or partially, with rubber tube drainage, as applied in other parts of the body, and the patient promptly placed under differential pressure after-treatment. That is to say, if a positive pressure cabinet or a negative chamber is available, one of these should be employed, preferably the latter; if not available, then any other device which will prevent the postoperative lung collapse. This treatment should be continued until the lung has become adherent to the chest wall, and the dangers of the occurrence of the postoperative pneumothorax have passed. This will be in from twenty-four to thirty hours, on an average.

There is no doubt that the incision of the lung is attended with many risks, the principal ones being: (1) opening of the free pleural cavity; (2) hemorrhage.

The annoying and sometimes dangerous complication of opening a free pleural cavity during incision of a lung abscess can be avoided, or its frequency at least be reduced by (*a*) a greater precision in localizing the diseased focus within the chest, on the part of the roentgenologist; (*b*) resection of a sufficient number and a sufficient length of ribs to permit reaching the place where the lung has become adherent.

As mentioned above, I trust that the further development of the method of roentgenography with the help of gas insufflation into the body cavities—in these cases the creation of an artificial pneumothorax for no other purpose than to find and localize the pleural adhesion or adhesions of the lung—will in the future frequently enable the surgeon to obviate the necessity of an exploration of the pleural cavity with the knife for the sake of precise localization of such adhesions. What we need is more clearly to define the exact place where adhesions between the two pleural leaves have formed, whether anteriorly, laterally or posteriorly, also at what level of the thoracic cavity, and thus render the same precision for the chest that pneumoperitoneum has afforded in diagnosing intra-abdominal adhesions.

If such diagnosis of the situation and extent of pleural adhesions could be definitely established, preliminary aspiration of the affected lobe, one or two days previous to the operation, so greatly desirable

in conservative lung surgery, yet so much and justly feared, will have lost its dangers. It certainly is a tremendous advantage, and greatly relieves the surgeon's mind, if all the important diagnostic questions have been definitely settled before he starts to operate.

The extent of rib resection to afford greater exposure of the lung surface, covered by parietal pleura plus endothoracic fascia, must, of course, be determined by clinical findings. Observation of the mobility of the lung during respiration through these two, normally very thin, membranes helps in recognizing the best place to enter the lung, and the color of the lung surface also represents a reliable guide. When the lung is diseased, the normal yellowish-pink appearance, revealed as it shines through the overlying membranes, gives way to a bluish-black discoloration. This is the place where the chronically inflamed lung usually has become attached to the chest wall.

B. BRONCHIECTASIS

The characteristics of this condition are: multiple lung suppuration of one or more lobes, of long duration; honeycomb appearance of the affected portion of the lung on cross-section, due to the presence of many scattered suppurating foci. Some of these show, in advanced and badly infected instances, calcified walls and strictured bronchial entrances, representing typical cesspools that harbor a fauna of partially anaerobic bacteria, which are principally responsible for the foul odor of the patient's sputum, the presence of easily bleeding granulations or irregular ulcerations, at or near the neck of these cavities, the former causing slight intermittent hemoptysis, the latter sometimes severe, eventually fatal, hemorrhages. A diffuse, putrid bronchitis is frequently coexisting.

This particular type of suppurating lung disease is, in the great majority of cases, probably dependent on a congenital malformation or arrest of development. Many authors believe that it is also due to the sequelae of the aspiration of a foreign body, or to the obliteration of the pleural cavity subsequent to an empyema; that means, to a uniform and broad adhesion between the visceral and parietal pleura of the affected portion of the lung.

An aspirated foreign body, solid or semisolid, will interfere with the free access and exit of air to and from a certain part of the lung, will obstruct, and being nonaseptic, will carry into the bronchial tree, with respiration, a continuously present, infecting and reinfecting agent. Such infection naturally produces inflammation and finally suppuration. However, it is hard to conceive, always thinking and speaking from the standpoint of the clinician, how aspiration of any sort could produce the typical classical picture of lung suppuration, which patho-

logically is termed bronchiectasis. Whether a fluffy foreign body, arrested within the lumen of a bronchus, for example, a bit of aspirated timothy grass which I observed as a causal factor in a case of diffuse lobe suppuration in a young boy, or whether a benign intrabronchial tumor will ever produce typical bronchiectasis, remains to be seen. Personally, I doubt it.

The patient suffers from a persistent cough, usually with a large daily quantity of more or less fetid sputum, which is often streaked with blood, but which does not show elastic fibers. It presents three layers on standing. There are clubbed fingers and toes, often irregular persistent fever, and metastatic joint affections may set in. The clinical picture is that of tuberculous lung affection; but tubercle bacilli in the sputum are always missing. The lung apexes are not involved, but other parts of the lung, principally the lower lobes, are affected, more so on the left than on the right side.

Clinical examination is often almost negative, particularly when the patient has just expectorated. The roentgenograms reveal diffuse opacity, sometimes with small cavities; the findings are often unsatisfactory. Bronchoscopy in the diagnosis more definitely defines the involvement.

I. *Medicinal and Hygienic Therapy.*—This is without effect.

II. *Specialistic (Endobronchial) Treatment.*—It stands to reason, and it has been my observation, that intrabronchial local therapy, viz., suction with antiseptic applications and irrigations of the bronchial tree, can but slightly improve this type of lung suppuration. It should be tried if operative advance appears absolutely contraindicated. Its effect will at best, if combined with posture expectoration, be subjective. Though rarely if ever reducing the amount of the sputum, it will reduce its foul odor, thus making the patient more comfortable. Still, there is no reason why bronchoscopists should not continue their investigations in this class of lung suppuration if the patients should be considered by the surgeon to represent too great a risk, or if they or their relatives should refuse radical operation; that means lobectomy.

III. *Conservative Operative Treatment.*—It should be emphasized here once more that, in gathering these personal experiences in the conservative operative treatment of subacute and chronic lung suppuration in the course of years, the differential diagnosis as to the various classes, as outlined above, was not made during the first years. Every case of advanced lung suppuration that did not seem to be a locally defined abscess was termed—and is still termed here, in reporting the brief histories of patients who in the beginning of our thoracic work came under treatment—bronchiectasis.

Of the conservative methods enumerated above the first three, viz., simple collapse of the affected lung by means of artificial pneumo-

thorax, intrapleural freeing of the lung from its adhesions plus artificial collapse, and extrapleural thoracoplasty do not impress me as promising satisfactory results.

1. *Simple collapse of the affected lung, in the absence of broad adhesions, accomplished by establishing artificial pneumothorax.*

Case 7.—A girl, aged 22, who was much reduced, with bronchiectasis of the right middle and lower lobe, had been sick for four years. In the spring of 1915, regular intermittent nitrogen insufflation was employed, covering a period of several weeks, through the courtesy of the late Dr. Whidden. No improvement resulted.

Other authors have tested the effect of artificial collapse of the lung in acute and chronic suppurating lung disease longer and oftener. Volhard succeeded in keeping the affected bronchiectatic lung, in an advanced case, collapsed for many months, with symptoms improved. When the patient and physician had become tired of this treatment, and it had been discontinued, allowing the lung to distend gradually, the original trouble reappeared in its former severity.

Tewksbury [7] of Washington wrote two very interesting articles on early artificial collapse in beginning lung suppuration after operations on the nose or throat, reporting ten cases with rather phenomenal clinical improvement, six cures and two deaths. The method promised to become the treatment of choice in this class of cases. Lately, Rich [8] has again recommended artificial collapse for the early treatment of lung suppuration. He reports ten cases: one following a pelvic operation; one following a simple cold; one following tonsillectomy under ether anesthesia; two following bronchopneumonia; four following the influenza bronchopneumonia syndrome. In several of these cases, the roentgen-ray findings made it certain that interlobar empyema preceded the abscess formation. It will be important and interesting to have the final results of these cases published after a number of years. It is hard to conceive how that method can compete with early bronchoscopic suction in suppurations due to aspiration.

2. *Operative intrapleural freeing of the lung from its adhesions and closing the chest, with the lung in a visibly complete collapsed condition, followed by subsequent gas insufflations.* We tried this method in Case 7:

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7. Tewksbury, W. D.: Acute Pulmonary Abscess Treated with Artificial Pneumothorax, J. A. M. A. **68**:770 (March 10) 1917; Treatment of Nontuberculous Lung Abscess with Pneumothorax, ibid. **70**:293 (Feb. 2) 1918.

8. Rich, H. M.: Acute Lung Abscess Treated by Therapeutic Pneumothorax, Am. J. M. Sc. **164**:428 (Sept.) 1922.

May 24, 1915, thoracotomy was performed in the negative chamber, superficial chloroform anesthesia being employed. The incision was made in the sixth intercostal space. The lung was nowhere adherent to the chest wall. The middle and lower lobes were visibly diseased, and partially atelectatic. Firm adhesions to the pericardium and diaphragm, also in the complementary space posteriorly, were loosened bluntly and divided between the ligatures. The lung was allowed to collapse, and the chest closed air-tight. The patient stood the operation nicely; and was wide awake when leaving the table. The recovery from the operation was uneventful. Gas insufflation was soon continued in order to keep the lung totally collapsed. There was no marked improvement in clinical symptoms. Relatives insisted on the patients discharge from the hospital, and she died at home several months later.

Comment.—The latter method of combating subacute and chronic lung suppuration has never appealed to me, nor has its use in tuberculous patients. If sufficient adhesions are present to prevent lung collapse by gas insufflation, and a conservative operative method is desired, collapse of the lung and the chest wall, with the help of multiple rib resection, appears more rational and logical. With all due care, the surgeon will often not be able to avoid tearing the lung parenchyma, thus inviting pleural infection.

How far thoracoscopy with division of adhesions, localized by direct inspection—the method inaugurated by Jacobaeus of Stockholm—will assist in handling such cases, the future must show.

3. *Extrapleural thoracoplasty, resection of from nine to ten ribs, without preliminary ligation of the branch of the pulmonary artery in cases in which adhesions between the two pleural leaves have rendered collapse by nitrogen or air insufflation impossible.*

Case 8.—A woman, aged 22, with bronchiectasis of the right lung, came under treatment at a time before the bronchoscopist had become the thoracic surgeon's faithful ally. Under local anesthesia, and, later on, a few whiffs of anesthol, the patient stood very nicely the resection of the ten upper ribs (inclusive of the first) in two sittings, Jan. 23 and March 8, 1915. However, she developed an empyema on the same side during the after-treatment of the second stage. With this drained, she was well at last and up and about, though little improved so far as the amount of sputum and other symptoms were concerned, when an acute suppurative meningitis developed, of which she died.

It is worth remembering that about one fourth of the patients afflicted with bronchiectatic lung suppuration are stricken by suppurative meningitis in the course of the disease (Tuffier).

Case 9.—A woman, aged 45, was extremely emaciated as a result of post-pneumonic suppurative affection. The sputum amounted to from 5 to 600 c.c. Daily expectoration in the pronounced knee-elbow posture brought great subjective relief. Under local anesthesia and very superficial anesthol general anesthesia, permitting conversing with the patient during the entire operation, resection of the tenth to the first rib, inclusive, was performed at one sitting,

Feb. 25, 1915. The patient stood the operation well, but continued to expectorate the same amount of sputum as before operation. She lived several weeks and then died of exhaustion. At necropsy a single old abscess cavity was found in the center of the upper lobe, and a second abscess, with the same characteristics, in the center of the lower lobe, presenting a picture of multiple typical lung abscess.

CASE 10.—A young man, aged 21, with bronchiectatic affection of the lower right lobe, whose family was opposed to any major intrathoracic operation, made an uneventful recovery after extrapleural thoracoplasty, with resection of the sixth to the tenth rib, inclusive, under local anesthesia, in December, 1919. Two years after operation, he reported no reduction in the quantity of sputum.

4. *Ligation of a branch of the pulmonary artery, with or without subsequent extrapleural thoracoplasty.* Sauerbruch and Bruns, in their experiments on animals, found that ligation of the branch of the pulmonary artery supplying the area of operation, which means eliminating the function of the lobe, produced a pronounced formation of connective tissue in that part of the lung, the latter becoming firmly adherent to the chest wall.

This operation was tested by Sauerbruch on fourteen patients, all of whom recovered from the operation. Twelve times it was combined with subsequent multiple rib resection. Great improvement, approaching a cure, was seen in two patients; two were very much improved; less pronounced improvement was seen in one; one remained unchanged; one, not improved, died of meningitis one and a half years after operation; the remaining seven, not improved, were subjected to lobectomy.[9]

Davies of London performed the operation once on a young man, aged 17, with great improvement of the disease. The left lower lobe was affected.[10]

My personal observation includes three cases:

CASE 11.—A young Italian, aged 17, who had been sick for five years, lately under sanatorium treatment, expectorated large quantities of foul sputum. Tubercle bacilli were never found. The right middle and lower lobes were affected. Bronchoscopic corroboration was not practiced at that time. April 4, 1912, the lower branch of the pulmonary artery was ligated in the negative chamber. Operation was begun under the novocain plus epinephrin anesthesia. An intercostal incision was made in the fifth space, down to the pleura. The lung was seen to move. The pleura was opened and a rib spreader put in place. Then superficial nitrous oxid and oxygen anesthesia was employed on account of continuous coughing and pressure. The lower portion of the lung, of dark brown appearance, infiltrated on palpation. There were many adhesions to the diaphragm, mediastinal tissues and at the apex. After blunt loosening and division of these, the lung could be brought forward. The interlobar space was obliterated, just marked by a fine line. An attempt at separation tore the

9. Sauerbruch, F.: Chirurgie der Brustorgane, Ed. 2, **1**:587, 1920.

10. Davies, H. M.: Surgery of the Lung and Pleura, New York, Paul B. Hoeber, 1920, pp. 219-221.

lung. Therefore, the lung was pushed outward, and held by an assistant, and the stem of the bronchus was palpated and exposed. The pulsating vessel on its upper surface was ligated with silk, as was also a second larger branch above, seemingly running to the middle lobe. Toilet of the pleural cavity was performed; complete layer closure of the chest without drainage was accomplished. Recovery was uneventful. A pleural effusion proved, on tapping, the presence of clear fluid which was sterile. Complete thoracoplasty of the second to the tenth ribs, inclusive, also of the rib cartilages, was performed under local and regional anesthesia, in three steps, four and one-half, six and eight weeks after the first operation. The patient was discharged improved, as regards quantity of sputum. He was presented to the New York Surgical Society. One year later, during the summer, he was admitted to the Post-Graduate Hospital with symptoms of suppurative meningitis, and died. Necropsy was not performed.

Case 12.—A young man, aged 17, greatly underdeveloped, had expectorated copious massive foul sputum for years. He had been in a sanatorium many months; but no tubercle bacilli had been demonstrated. The left lower lobe was involved. Operation was performed, April 25, 1912, in the negative chamber. It was begun with local and regional anesthesia, later nitrous oxid and oxygen being employed. A seventh intercostal incision was made. The portion of the lung that appeared was not adherent to the lateral chest wall, but at other places it was. The lower lobe was densely infiltrated on palpation, and not loosened. The interlobar space could be entered nicely; but it was closed so tightly by adhesions, farther down toward the main bronchus, that advance was not pressed. Again, the lung was held outward by the first assistant and the stem-bronchus approached as in Case 11. When the adhesions were gently pushed away with a stick sponge, the upper branch of the pulmonary artery appeared. After further careful dissection, the lower branch also soon came into view. A swollen lymphatic gland rested in the angle of the fork. The lower branch was ligated. Complete closure of the chest was accomplished without drainage. The patient stood the operation nicely. Two days later, some subcutaneous emphysema appeared in the lower half of the abdominal wall, on the left side. A turbid serosanguineous effusion into the left pleural cavity, found on tapping, required partial reopening of the wound. After that, the recovery was slow but satisfactory. One year later, the patient was much improved. There was a great increase in weight; expectoration was reduced to 100 c.c. in twenty-four hours. May 15, 1913, a thoracoplasty was performed, under local and regional anesthesia, the sixth to the tenth ribs, inclusive, being resected in their entire length. Recovery resulted. Two years later there was a decided improvement, but the patient was not cured. Further surgical interference was refused by the family. The patient was lost sight of.

Case 13.—A man, aged 22, an architect, very intelligent, had bronchiectasis of the right lung involving the lower lobe. There were few clinical signs; very foul copious sputum, from 3 to 400 c.c. in twenty-four hours, often tinged with blood. No bronchoscopic corroboration was possible. The roentgen ray revealed dilatation of the right bronchus and diffuse infiltration of the lower lobe. Feb. 25, 1913, ligation of the pulmonary artery of the right lower lobe was performed, in the negative chamber, under regional and local anesthesia, through a fourth intercostal incision. The lung was found not adherent. Placing of the rib spreader gave the patient a "severe pressure sensation." On account of reflexes when the lung was handled, a few whiffs of anesthol were given, not more than 5 c.c. being used in all. Then operation was continued under local anesthesia as before. The pericardium was tightly adherent to the lung; cardiolysis was performed. There was a well marked interlobar space; adhesions within were gradually

loosened until the main bronchus was reached. During this manipulation, the lung was slightly injured. When the patient pressed, some mucopus escaped from the small sized bronchial opening. The vagus branch was recognized; repeated application of absorbent cotton, thoroughly soaked in 1 per cent. novocain and epinephrin solution, were made on the bronchial root. Hardly any reflexes were noticed afterward. The artery to the "north" of the bronchus was carefully loosened and ligated with silk. In view of the possible infection of the pleura by way of the exit of bronchial secretion, free drainage of the pleural cavity was established through an incision posteriorly in the ninth space. The chest incision was closed. The patient was retained under differential pressure for twenty hours, when he was in good condition. Two days later, some subcutaneous emphysema appeared over the lower abdomen, the right half of the scrotum and the left side of the neck, with increase of temperature. The posterior angle of the wound was opened. Some serosanguineous and clear fluid escaped. He was soon out of bed. Recovery followed. Three years later, the patient wrote from Georgia that cough with expectoration often occurred only once a day. Sputum amounted to 15 c.c. in twenty-four hours. His general health was perfect, and he was at work in out-of-door construction. In the spring of 1922 he was still living in the South and married. His general condition was excellent. There was no cough. Expectoration had ceased completely. He considered himself cured.

Epicrisis.—It sets one to thinking when one sees a patient, who was thus afflicted, so much improved after this operation that in a suitable climate he could reenter business and become a useful self-supporting citizen, and that such result was obtained even without a subsequent thoracoplasty, which had been proposed but was not accepted by the patient.

Comment.—It is important to remember that the pulmonary artery lies "north" of the bronchus, toward the patient's head. The operation may be technically difficult on account of firm adhesions between the lobe surfaces themselves, the affected one forming a unit with its neighbor. On separating these adhesions, no matter how gently done, the lung tissue is easily torn, an occurrence which naturally at once carries an infectious element into the otherwise aseptic operation. Such occurrence requires categorically air-tight drainage, a procedure which I employ after any and every intrathoracic operation.

5. *Resection of the lung.* In one instance, I tried this operation before resorting to lobectomy, the patient having requested me to take as little chance as possible in the course of the operation.

Case 14.—E. W., a widow, aged 53, with no children, with bronchiectasis of the left lower lobe, had been repeatedly operated on at another hospital. Her present trouble commenced in January, 1910, and was evidently consecutive to an intrapulmonary abscess following pneumonia with empyema on the left side. A fistula persisted. Injected bismuth paste was coughed out. Multiple rib resection brought no improvement. On admission to Lenox Hill Hospital, examination revealed a long scar in the chest wall; at about its middle, posteriorly, it afforded wide entrance into a lung cavity showing many open

bronchi. The patient was well educated and determined to secure relief. May 8, 1914, under general anesthesia in the abdominal posture, the scar was circumcised, with reresection of the tenth to the sixth rib; an additional resection for some length of the fifth rib, which had not been touched at the former operation, was performed. The scapula was held aside, and advance arranged in such a way that the opening into the lung remained in the center of the operative field. The costal pleura was divided below the fistula, exposing the lung, which was gradually loosened entirely from the complementary space where it was tightly adherent. At last the thickened pleura with the overlying tissues was excised. Then the pulmonary cavity was laid wide open with the cautery. It was seen that there were at least ten to fifteen various openings of the bronchial tree. In view of the fact that the lower lobe was completely adherent to the upper and could have been separated from it only by a free division, necessitating special suture of the upper lobe, as well as in view of the patient's general condition and age, it was deemed wiser to resect the lower lobe than to extirpate both. Two curved clamps, as used in gastro-enterostomy, covered with rubber, were placed on either side of the open cavity converging toward the hilum, and then the diseased portion was excised in the shape of a wedge with the knife, leaving a sufficient amount of tissue in front of each clamp. Careful disinfection (pure phenol and alcohol) and ligation of the open bronchi with the accompanying blood vessels were accomplished. On removing the clamps, only a few additional ligatures were required. Then an inverting suture of each remnant of the lobe with chromicized gut, starting at the periphery, was inserted. Finally two rounded taillike portions remained, which were sutured on each other. Tamponade and drainage were established. The patient stood the operation nicely. Recovery was good. Three weeks later, when the patient was required to press, with compressed nostrils and mouth closed, bubbles of air could be heard escaping from the lung; one larger sized bronchial fistula developed. Prolonged after-treatment exhausted all methods employed for closing this type of fistula. The fistula finally did close; but then there was more expectoration, from 50 to 100 c.c. in twenty-four hours, with the patient rather sick. The lung was reopened, causing a copious purulent discharge. The good general condition returned, proving that it can be maintained with free pulmonary drainage only. The patient was referred to a home for tuberculous patients, the only institution willing to admit her.

Comment.—Although I have only this one personal experience with lung resection at my disposal, I, nevertheless, after mature consideration of the subject, think that I am justified in saying that this operation has no place in the operative treatment of chronic lung suppuration. It would certainly be mere luck if the excised wedge of the lung should radically remove the diseased area. The operation, therefore, will likely improve only the pathologic condition. Of course, if a patient or his relatives will not accept the risk of lung excision, and it can be arranged to place the expected fistula within the immediate view and reach of the patient, the removal of the greater portion of a suppurating lung lobe might, after all, receive a place among the operations that are in use at present for the surgical treatment of chronic pulmonary suppuration on more conservative lines.

6. *Incision and drainage.*

CASE 15.—A man, aged 24, four months before had had his adenoids and tonsils removed. Shortly afterward, beginning lung suppuration developed. Later, high fever with rapid pulse developed, together with continuous cough and foul sputum in great quantities (500 to 600 c.c. in twenty-four hours). The roentgen rays added little to the accuracy of the diagnosis. Bronchoscopy at that time was not yet raised to its present position of imperative diagnostic addenda. The patient entered Lenox Hill Hospital, Nov. 2, 1911. Aspiration of the lung in various places was performed. In the seventh intercostal space near the angle of the scapula where some bronchial expiration was noticed, pus was found about 2½ inches (6.7 cm.) below the surface. Operation was performed November 6, under local anesthesia. The seventh rib was resected, aspiration was repeated and positive. The lung was opened with the electric cautery. An irregular cavity was entered, the size at least of a small apple. On dividing the lung, the free pleural cavity was accidentally opened toward the front. No collapse of the lung occurred evidently owing to its being attached to the costal pleura in various places. A drain was placed in the pleural cavity with gauze packing of the abscess. Gradual closure of the large wound occurred by granulation. A drain was left in place permanently to produce persistent drainage to the surface. Frequent paroxysmal coughs occurred. The quantity of sputum was greatly diminishing. The patient was discharged, December 20. A few weeks later, while the family was preparing to move to the country, the patient was suddenly stricken with acute suppurative meningitis, to which he succumbed within six days.

Epicrisis.—Today, a patient of this type would, in my hands, first be transferred to the bronchoscopic clinic for intermittent prolonged treatment before I would resort to operation.

CASE 16.—A girl, aged 19, who had been sick for sixteen years, subsequent to pneumonia (?), expectorated extremely fetid, massive sputum with cough. She had to leave her place of business and was confined to a room by herself, later being isolated at the Montefiore Hospital for seven months. The clinical symptoms were not clearly marked. There were few râles on the left side and some dulness near the spine. The roentgen rays corroborated left side infection. On aspiration below the angle of the left scapula air and pus, in a small quantity, were withdrawn. Jan. 21, 1914, operation was performed at Montefiore Hospital, in two stages. Regional and local novocain and epinephrin anesthesia was used. Resection of the seventh and eighth ribs in the posterior axillary line with excision of intercostal soft tissues was performed. Aspiration in the bed of the seventh rib was again positive for pus. On disengaging the syringe from the needle, pus spurted from its hub synchronous with inspiration. On cauterizing alongside the needle with a Paquelin cautery a free pleural cavity was entered, but acute pneumothorax did not ensue, evidently on account of adhesions in other places. The lower lobe of the lung was much solidified. The operation was discontinued and the needle withdrawn from the lung. Tube drainage plus gauze tamponade of the free pleural cavity was established. The lung was stitched to the costal pleura in order to have sufficient space for opening at the second stage. Three days later, the first dressing was changed, the pleural tampon being left undisturbed. Aspiration of the lung was again positive. The cavity, opened with the active cautery, admitted easily one half of the fore-

finger. On pushing the needle in another direction from within the lung wound, a second cavity was entered and opened with the cautery. The two were purposely not transformed into one, as a serious hemorrhage might have set in. Separate tamponade was performed. Undisturbed convalescence ensued. The free ventilation of the lung cavities did away quickly with the foul odor of the sputum. After a few weeks, the patient was transferred to the ward, to her great delight, after the long isolation. She was discharged after six weeks. The advice to retain the drain as long as possible was not heeded, the wound being dressed by the family physician out of town. When the drain dropped out accidentally it was not replaced. The patient returned to business, and was last seen in October, 1920. There was occasional cough with scant expectoration; expiratory air had a slightly sweetish odor. She was at work, and hers should be considered an improved case.

Comment.—Mere incision plus drainage of one or two of the many cavities within a typical bronchiectatic lung cannot possibly bring real help in these cases, for obvious reasons. Such drainage will direct the secretion of only a small part of the involved area to the surface. With the closing of the incision, the original suppuration continues unabated. Besides, suppurative meningitis is a fearful menace in 25 per cent., and more, of these cases.

"Action," frequently "daring action," is necessary. That means:

IV. RADICAL OPERATIVE TREATMENT

Excision of the diseased portion of the lung is here, therefore, absolutely and clearly indicated, if the patient or his relatives are willing to take the risk for the sake of the possibility of a complete cure.

Before discussing the third subdivision, the bronchiectatic lung abscess, I shall say a few words regarding my personal experience with lung excision, as well as with the treatment of lung suppuration due to specific infection (tuberculosis and syphilis), and give a brief résumé of experience, gathered by others, in suppuration due to the presence of a benign intrabronchial tumor and a personal observation of suppurating cancer of the lung.

A few cases of lung suppuration, hard to classify, that have come to operation at my hands, will be added, in order to make this personal survey complete.

Lung Excision.—In four cases the operation remained an attempt that failed; twice, only the first part of the planned two-stage excision was performed, an intercurrent pneumonia frustrating the second. In one case, the entire right lung was successfully excised, and surgical conditions remained favorable after the operation; but the patient developed a most fulminant pneumonia of which he died, the night following the operation.

Briefly and chronologically reported, the cases are as follows:

Case 17.—A boy, aged 6 years, was operated on, May 12, 1909 (reported above), for congenital, advanced bronchiectasis of the left lower lobe. General anesthesia was used, with the patient's head in the positive pressure cabinet. He died suddenly when the bronchus was being tied, after the accompanying blood vessels had been ligated. Necropsy was not performed.

Case 18.—This was the case of resection of the lung, reported before (see above). A. W., woman, aged 54, was unhappy in the home for tuberculous patients, and urged operation. She could have continued to live for some time in the present condition with some attendance; but she was dependent on others as the wound was in the back. Personal reasons were accepted as the real indication for operation, performed, Dec. 22, 1915. Local plus regional anesthesia was used, later on, general anesthesia, with anesthol and oxygen. Circumcision of the sinus quickly exposed and gradually freed the lung. A rent in the pericardium, which contained some serous fluid, was sutured. Additional division and partial resection of four more ribs were required to expose the organ fully. As mentioned before both lobes formed a unit. The upper seemed to be as much diseased as the lower was before resection, pus flowing out in abundance at a place which had been superficially torn on loosening the adhesions. There were firm attachments also at the apex. They could be divided between the ligatures so that at last a good pedicle was formed, the stem bronchus being reached. The pneumogastric nerve was pushed off and plainly visible and might have been cocainized without difficulty. Having some little time before successfully performed extrapericardial ligation of the left pulmonary artery for total excision of the lung in experimental work, and being aware that in the upper lobe branch a good deal of granulation had been seen by the bronchoscopist, primary division of the bronchus with local treatment of the bronchial mucosa appeared at that time more desirable than primary tying with a mass ligature. So it was decided to ligate the left main trunk of the pulmonary artery separately first. The latter's course was easily visible, and it was approached at the root of the bronchus where the thin sheath that covers it was divided. With the curved tip of the left forefinger supporting the vessel from beneath, a large Deschamp's needle was made to surround it from the front, most gently. Suddenly, a fearful hemorrhage occurred from the posterior aspect of the artery. Evidently, the Deschamp's needle had perforated the vessel in spite of the gentle handling, there having been no resistance whatever offered from the latter's wall. The blunt needle had passed through it as easily as if it were penetrating jelly or soft butter. Compression with gauze was applied, and an elastic ligature quickly thrown around the base of the pedicle, which, however, on testing, was found not to embrace the injured place of the vessel. While the artery was being clamped, the patient died, probably as a result of aspiration of air into the circulation, and also surely from the sudden great loss of blood.

Epicrisis.—Should it be thought best in any given operation to ligate the main trunk of the pulmonary artery, only very blunt instruments should be used for separation, e. g., a closed blunt, broad Cooper's scissors or Kocher's goiter probe ("Kropf-Sonde"), or, still better, the tips of the two forefingers of the surgeon. Any half-ponted, though blunt, instrument should not be used on account of the extreme softness of the vessel's wall.

CASE 19.—A woman, aged 35, with suppuration of the right upper lobe, was operated on in October, 1916, excision being decided on without careful weighing of the indication for incision or excision. Pharyngeal anesthesia in the negative chamber was employed, the latter being used should differential pressure be required. After rib resection, loosening of the totally adherent lobe started, when a remarkable, multiple arterial hemorrhage set in, not unlike the spray from a garden sprinkler under pressure. It probably was due to having entered a wrong point of cleavage, stripping off the two firmly united pleural leaves plus the intrathoracic fascia from the chest wall. Operation was temporarily stopped. The patient recuperated after intravenous infusion. The work was continued; all three lobes formed a unit. While trying to separate the lower lobe from the middle and upper, increasing collapse occurred on the table and the patient died. Necropsy revealed a central single abscess in the upper lobe.

Epicrisis.—More detailed roentgen-ray localization and incision with drainage might have saved the patient. Since that time the surgeon's proficiency in making a more refined diagnosis has been much increased. We have also learned to demand establishment of a stricter indication for the type of operation to be carried out on recognized pathologic facts in the given case.

CASE 20.—A man, aged 53, in whom the entire left lung was involved in a suppurative postpneumonic process, the bronchoscope proving the right lung free, was operated on April 16, 1917, with intratracheal insufflation, Torek's incision in the eighth intercostal space being made. Four ribs were divided upward. The lung, which was totally adherent, was loosened with difficulty, a few superficial tears occurring. The collapsed lobes were surrounded with gauze tampons, according to Robinson's advice. The thoracic wound was then closed with air-tight drainage. An interesting result of the latter was that 250 c.c. of secretion drained into the bottle in the first twenty-four hours, 700 in the second, 600 in the third, and 400 in the fourth. On the third day after operation, the patient complained of difficulty in expectoration and developed clinical signs of increasing inflammation, likely pneumonia, on the collapsed side, to the sequelae of which he succumbed on the fourth day after operation. Wound inspection revealed no aspiration process on the opposite side.

Epicrisis.—A one-stage operation removing the entire left lung might have offered a better chance of recovery.

CASE 21.—A woman, aged 23, was suffering from suppuration of the right upper lobe subsequent to tonsillectomy. Other parts of the lungs were not involved, as proved by bronchoscopy. She was a trained nurse, utterly unhappy, unable to sustain herself financially and considered herself a burden to her family. The case demanded radical help. Operation was performed, Nov. 10, 1916, with intrapharyngeal insufflation. Torek's incision was made in the seventh intercostal space. The lung was without adhesions, except in the upper lobe, which was particularly broadly adherent at the apex. These were freed by double ligatures and division between them. The base of the pedicle of the upper lobe could be surrounded by the surgeon's forefingers. It was rather massy. The upper and lower lobes formed a firm unit with the middle. An

attempt at separation was only partially successful between the middle and lower lobes. While trying to form a pedicle from the periphery toward the center, after having placed compressing clamps and ligating the tissues with the help of chain sutures, severe hemorrhage with sudden death occurred, probably due to aspiration. A postmortem incision of the upper lobe revealed a central abscess, the size of a small walnut, as in Case 19.

Epicrisis.—The primary tying of the pedicle, though it was very broad, with a piece of tape or an elastic ligature, before starting to separate the lung tissue from the periphery toward the center, in forcing lobectomy, or, from the start, after refinement of the diagnosis, employing a more conservative program, namely, pneumotomy plus drainage, after successful localization of the cavity, might have saved this patient's life.

In the light of present knowledge, bronchoscopic treatment was indicated as the first step in aggressive therapy.

Case 22.—In a boy, aged 5½ years, with copious purulent expectoration, resulting from bronchiectasis involving the entire right lung, repeated aspiration by means of the bronchoscope (Dr. Lynah) brought no improvement. Operation was performed, April 26, 1920, with intrapharyngeal insufflation. An attack of cyanosis with respiratory syncope occurred in the course of the operation. Torek's incision was used, affording perfect exposure. Multiple broad firm adhesions, doubly ligated and cut, obtained good isolation of the broad pedicle. Primary clamping in a line parallel with the spine; amputation of the entire lung; careful hemostasis by surrounding the pedicle in front of the clamps with a large round needle and chromicized catgut in sections; careful loosening of the clamps; no hemorrhage, and air-tight drainage in the ninth intercostal space were accomplished. The patient left the operating table in good condition. In the evening, the pulse was good; respiration, somewhat accelerated; he was cheerful and took fluid. During the night, the temperature suddenly rose to 107 F., with corresponding acceleration of pulse, which did not respond to stimulation. He died at 2:30 a. m., ten hours after operation. Partial necropsy revealed edema of the left (remaining) lung (acute fulminant pneumonia?); no evidence of aspiration. Perhaps the cyanotic attack in the course of operation ushered in the severe inflammatory attack.

Pathologic diagnosis of the specimen was: lymphosarcoma of the lung; bronchiectasis; no metastases.

Case 23.—A youth, aged 17, had had voluminous purulent sputum for years, without fetid odor. No aspiration of any kind had occurred. There was no history of pneumonia. Evidently the case was congenital bronchiectasis of the left lower lobe. This was corroborated by roentgenography and bronchoscopy. Resection of the lobe was clearly indicated. Operation was performed, March 30, 1922, in the negative chamber, with general anesthesia. Torek's incision was made in the seventh intercostal space. The lower lobe was of the same, normal pink color as the upper, but, as a whole, more resistant on palpation. There were no adhesions whatever. For this reason, the original program of immediate lobectomy was abandoned in favor of a two-stage operation. The visceral pleura of the upper lobe and the parietal pleura

in the upper half of the chest cavity were thoroughly rubbed with a piece of sterile gauze. The upper lobe was then surrounded with seven iodoform gauze tampons; a piece of rubber dam enveloped the artificially collapsed lower lobe. The thoracic wound was carefully closed, layer by layer, by means of interrupted chromicized catgut sutures. The tips of the seven iodoform gauze tampons were tied with silk thread and buried below the subcutaneous fascia (Lilienthal). Air-tight drainage of the pleural cavity was not arranged for, as it was intended to use it for the second stage operation. The patient stood the procedure nicely, and passed a comfortable night. The next day there was a rise of temperature, rapid respiration and pulse, some dyspnea with cyanosis. Twenty hours after completion of the operation, aspiration of the pleural cavity with the needle and syringe filled the barrel with air, not fluid. The insertion of a small trocar, with an attached rubber tube, the tip being held under water, gave exit to a large amount of air. The dressing was well soaked with fluid wound discharge. After this, the patient was much improved. The next day the temperature was rising and aspiration was repeated, but neither air nor fluid was obtained. Change of dressing was accomplished under pharyngeal oxygen pressure. On removing the stitches over tampon tips, a large amount of serosanguineous fluid escaped. The tampons were quickly removed and air-tight drainage provided for, the tube being placed where the tampons had been removed. The patient passed into profound collapse when returned to bed and died six hours later, with rising pulse and temperature, in spite of stimulation of every possible type. Only wound inspection was permitted. Both lobes of the left lung were in complete collapse. There was no more fluid in the chest. The lower lobe, removed, showed a typical picture of bronchiectasis.

Epicrisis.—1. A one-stage operation should have been the choice in spite of absence of adhesions.

2. Evidently, a quickly increasing serosanguineous effusion, not reached by the aspirating needle, forced its way through the interruptedly stitched layers of the chest wall to the surface, allowing air to enter the pleural cavity, thus producing a hydrohemopneumothorax.

3. The continuous buried suture for the various layers of the chest wall seems preferable to interrupted sutures.

4. Air-tight drainage, added at the completion of the first stage of the operation, might have saved the patient. Had it been employed and had the patient survived the first stage of the operation, sufficient adhesions between the two pleural leaves over the upper lobe would probably have made air-tight drainage at the conclusion of the second stage unnecessary; or, in the absence of adhesions, retaining the patient under negative or positive pressure after the lobe resection for from one to two days, with the chest wound wide open, might have sufficed to bridge over the dangers of a flopping mediastinum.

COMMENT

The thoracic surgeon should also publish his negative results. In carefully analyzing the cause of death, often much light is shed on

what might better have been done in a given case, and such reflections, jotted down by the individual man and published, will often be a guide to the workers in this new field of operative surgery in similar cases.

The impression I have had from these operations and observation of these patients is:

1. It is, it seems to me, the insistence on refining the diagnosis as much as possible and selecting the operative treatment on strict indication, carefully weighing the pros and cons before starting the operation; further, the absolute attempt on the part of the surgeon to avoid such accidents in the course of the operation as can be avoided nowadays by proper preparation, which will quickly further the advance of this branch of thoracic surgery.

2. It should be explained to the patient who suffers from typical bronchiectasis, that bronchoscopic treatment and incision with drainage promise no hope, and life would continue to be a misery; therefore, the risk of radical operation, lobectomy, should be undertaken.

3. It is not wise to enter the chest with a cut and dried program, to be carried out at all hazards, but rather to be guided by local findings as in operative procedures in other parts of the body.

4. Every effort should be made to make lung excision a "one-step procedure." It stands to reason that it must be better for the patient not to be obliged to submit to a second operation soon after the first.

5. If the one-stage procedure appears to be contraindicated, air-tight drainage is advisable after the first operation, in view of the marked tendency of the pleura quickly to produce a large exudate, especially when foreign bodies, such as tampons or rubber dams, have been left within temporarily. It seems safest for the patient that this exudate which always occurs should drain off from the start. The second stage of the operation, with the subsequent after-treatment, can then be conducted as in any other operation, viz., without differential pressure on account of the presence of adhesions. Should the latter have failed to form sufficiently, and drainage appears again imperative at the completion of the second step, the temporary maintenance of the patient under differential pressure, as mentioned before—negative chamber, positive cabinet, positive oxygen pressure with the help of the mask, or any kind of suction apparatus—will effectively help out.

6. We must learn how to reduce the ever imminent danger of aspiration pneumonia, subsequent to general anesthesia. Sauerbruch considers general anesthesia a necessity for intrathoracic work and calls it a "technical mistake" to try anything else. Yet it is to be hoped that means will be found in the course of time to do also the intrathoracic work, at least in certain cases of subacute and chronic lung suppuration, under some kind of local anesthesia, in order to enable the patient

to expectorate at will throughout the operation. Perhaps the filling of the chest with a nonpoisonous solution of a local analgesic, or a carefully worked out plan for regional anesthesia, will help, or, if such hope cannot materialize, a very superficially conducted general anesthesia, with an anesthetic that does not stimulate mucus discharge, as, for instance, anesthol or chloroform, or an expertly conducted general anesthesia with nitrous oxid and oxygen in the hands of a man who knows—"team work"—will do it. The third case of ligation of a branch of the pulmonary artery, done for typical bronchiectasis, reported above, was almost completely done under local anesthesia.

7. The principal points to be observed during lobectomy are: (*a*) the safe sealing of the bronchial stump during operation—blood vessels and bronchus; (*b*) arrangement during the operation for meeting the dangers of the usually occurring bronchial fistula when the ligatures of the stump come off, the chest having been tightly closed.

In view of the fact that proper treatment of the stump is the principal point in lobectomy, and that it has been seen that experience gathered in experimental lung surgery cannot be transferred to human pathology in this field, separate ligation of the branches of the pulmonary artery and vein, with air-tight closure of the infected and impregnated bronchial stump, becomes inadvisable or impossible in man. The stump, therefore, is to be treated en masse. Friedrich [11] used for this purpose his hilum clamp. Others employed a mass ligature of silk or rubber, providing against the subsequent leakage by gauze tamponade, or they closed the chest and risked the consequences of the expected air leakage. Howard Lilienthal [12] of New York in his classical article on resection of the lung advises treatment of the stump with multiple penetrating silk sutures, piercing it repeatedly with needle and thread and tying the threads most carefully. Each ligature thus placed grasps and secures indiscriminately a portion of the stump. At the end of the procedure, the blood vessels and bronchus are found to be safely closed. He leaves the threads long, marks their collected ends by a safety pin and buries them temporarily under the skin, while the immediate after-treatment, wisely, is conducted under air-tight drainage. When the first days have passed, the wound is partially reopened, and the thread ends are exposed. They enable the operator to extract the gangrenous stump as a whole later on, when Nature has safely sealed the large divided blood vessels. The resulting bronchial fistula or fistulas usually close by granulation. The deeper it is situated, the greater is the chance of perfect cicatrization.

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11. Friedrich: Arch. f. klin. Chir. **82**:1171, 1907.
12. Lilienthal, Howard: Ann. Surg. **75**:257 (March) 1922.

Surgeons, as a whole, will do best, it seems to me, to follow Dr. Lilienthal's carefully worked-out technic, because he has seen with it more actual recoveries than any one else in the world and has succeeded in reducing the mortality to 45 per cent., a splendid achievement.

Still, I believe that other methods of treating the stump can and will gradually be worked out, which will also prove useful. And this, I think, will happen as soon as lobectomy has come into more general use, and that, there is no doubt, will occur in the near future.

In my mind I have always compared the extirpation of the lung with that of the kidney, at least as far as the immediate treatment of the pedicle is concerned, and I could never forget in this respect the observation made by the late Professor Czerny of Heidelberg in his early cases of nephrectomy. At that time he was in the habit of securing the broad pedicle of a suppurating kidney with a needle and thread, perforating it as chance arranged it. One of the patients died from acute sepsis, although the wound had been properly drained. At necropsy it was seen that the needle had pierced the renal vein, and the ligature consequently gave a direct route for the bacteria to enter the circulation. Czerny attributed the fatal issue in that case to his method of stump treatment. From that time on, he used a mass ligature of strong material which surrounded the entire pedicle of the kidney a number of times. I should consider it also good surgery to compress temporarily the lung lobe stump, the bronchus and the blood vessels, with a useful, adaptable instrument; amputate the lobe, from 1½ to 2 inches (3.5 to 5 cm.) in front of the same, and then, after proper separate ligation of the visible cut ends of the blood vessels, disinfect and close, after the usual crushing, the bronchial stump, or cover it, in addition with retained lung tissue, as the surgeon may think best. Having watched the working and the many advantages of Sehrt's metallic tourniquet in limb amputation,[13] I planned to try small metallic tourniquets, manufactured on the same principle, "Baby-Sehrts," in lung extirpation. So far, I have had three sizes made by George Tiemann & Company of New York, 5, 4 and 3¼ inches from end to end (Fig. 3). I had them ready for use in my last case planned for lobectomy (Case 7), but did not have the opportunity to test their usefulness, because the absolute absence of adhesions made me, much to my present regret, decide on a two-stage operation. It is possible that these instruments will prove of value in the technic of some cases of lobectomy, inasmuch as with them the pedicle can, by means of a thumb screw, be compressed gradually and at will, just enough to control hemorrhage. If, on loosening the tourniquet, the control should prove incomplete, a

13. Meyer, Willy: Ann. Surg. **72**:763 (Dec.) 1920.

turn of the thumb screw restores immediately the former safe condition of hemostasis. I am expectantly looking forward to my next case, in which I may test the device.

In conclusion, just a word regarding the necessity of the performance of necropsies in thoracic work. Here, as in other fields of thoracic, as well as of general, surgery, the postmortem examination, or at least a wound inspection, is most essential for proper progress. We MUST KNOW whether pneumonia (usually due to aspiration during or after our work, eventually also due to loss of body heat, in consequence of prolonged exposure of the patient and his very large wound in too cool a room), or whether septic infection, consecutive to the surgeon's imme-

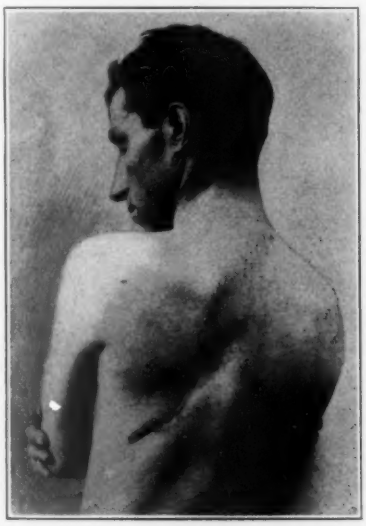

Fig. 2 (Case 3).—Typical postpneumonic lung abscess cured by incision. Localization not definitely determined before operation; free pleural cavity entered and lung adhesions made out by palpation from within; abscess aspirated at this place and incised at the same stage. The opened free portion of the pleural cavity closed by suture; air-tight drainage established, resulting in cure.

diate work at the time of operation, or a hemorrhage, or a wrongly selected method of after-treatment, inviting infection, is responsible for the fatal issue. Only in this way will thoracic surgery make the safe and quick progress it needs. Also, for this reason, it is to be hoped that the cases of all patients operated on will be reported in the literature irrespective of whether they ended in recovery or death.

TUBERCULOSIS AND SYPHILIS

1. *Tuberculosis.*—It must be a comfort to patients suffering from advanced pulmonary tuberculosis, particularly those with cavity forma-

tion, to know that when all other specialties in medical science have exhausted their therapeutic possibilities, surgery may still bring help in from 60 to 70 per cent of the cases. The two-stage or three-stage extrapleural thoracoplasty is the operation of choice. It can be combined, if necessary, with apicolysis (loosening of the apex of the lung) plus fat (Tuffier), or paraffin (Baer) filling of the resulting cavity, or with flap formation and implantation of the pectoral muscles (Archibald), as well as with resection of the phrenic nerve, to produce paralysis of that half of the diaphragm. Placing the affected lung in

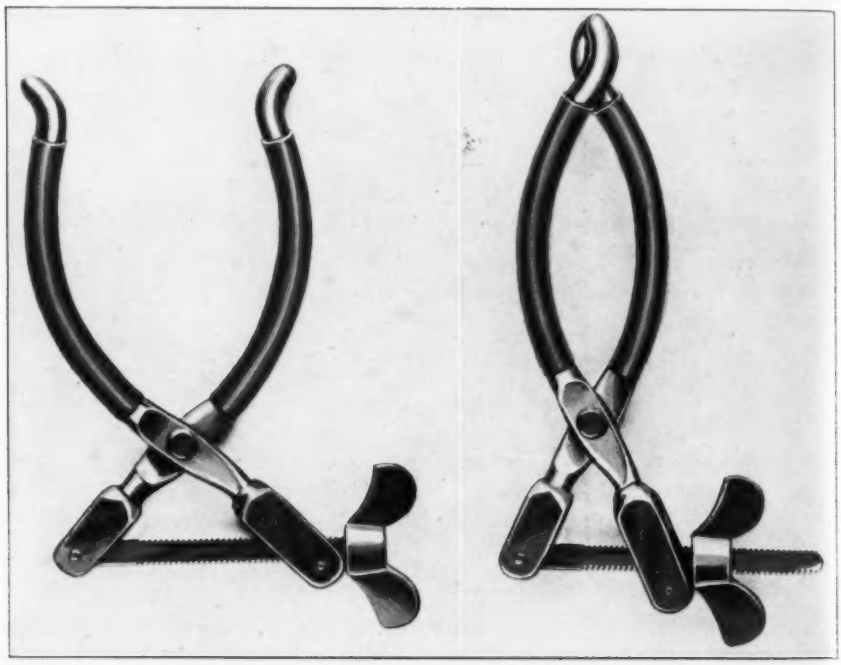

Fig. 3.—"Baby Sehrt" metallic tourniquet, designed for the compression of the pedicle of the lung in lobectomy; made in three sizes; No. 2-4 inches illustrated here, about one fourth actual size.

this way at perfect rest and compressing it as much as possible from all sides, with an elastic pad, after the rib resecton, from without, paves the way to success. Massive connective tissue formation, substituting the affected lung tissue and encapsulating the tuberculous foci, explains the good results pathologically.

The work should be done under local and regional anesthesia if possible. Proper selection of the cases, in conjunction with a medical expert in lung tuberculosis, is necessary.

These patients should best be operated on in our general hospitals, which should put aside one or two rooms for this purpose. Careful

nursing with the strictest surgical supervision during the first days after operation is imperative.

My personal experience covers four cases. Briefly stated, they are as follows:

CASE 24.—A man, aged 26, with an advanced case of bilateral affection, in which the left was worse than the right, was operated on in two stages, Nov. 18, 1918, and Dec. 10, 1918, at the Lenox Hill Hospital. The ribs, from the second to the tenth, inclusive, on the left, were resected. The patient is cured and well at the present time. Tubercle bacilli, cough and sputum have disappeared. He lives in Texas; is in business, and engaged to be married.[14]

CASE 25.—A man, aged 36, with bilateral far-advanced disease, was sent in from outside. He was desperate and begged for operation. Personal, wrongly placed humanitarian sentiments induced me to yield. Operation, first-stage, was performed in January, 1919, at Lenox Hill Hospital. The tenth to the sixth ribs were resected under regional and local anesthesia. The operation was well borne; but preoperative fever continued to rise. He returned to the mountains and died. Partial necropsy revealed pronounced disseminated (miliary) tuberculosis of the opposite lung, less pronounced on the side on which operation was performed. This was a rare occurrence after this plastic operation.

CASE 26.—A woman, aged 35, was sent from outside with bilateral advanced multiple cavity formation. A New York specialist in tuberculosis whom I consulted was unable to say which side he should pronounce the more affected. Again humanitarian sentiments gained the upper hand, when establishing the indication. The first-stage was performed on the side first attacked by the disease, at the Montefiore Hospital, in May, 1921. The tenth to the sixth ribs were resected under local anesthesia. The operation was well borne. The patient was somewhat easier and under nurses' continuous observation. During the second-stage, June 18, when resecting the fifth to the second ribs, inclusive, further collapse of the lung produced dyspnea on the table which continued in spite of stimulation. There was no change in the hectic fever. Death occurred on the sixth day after the second operation.

Epicrisis.—In this case, too, I wrongly felt that I was under personal obligations to the colleague who had sent the patient to me. I also had pity for the patient, for refusing the desired operation meant robbing her of her last ray of hope. Such sentiments, however, should not be allowed to confuse the surgeon's decision; strictest indication, built up on cold clinical facts, in consultation with a trained specialist in tuberculosis, is absolutely imperative in our attempts to treat surgically tuberculosis patients in the advanced stage of the disease.

CASE 27.—A man, aged 26, well preserved, had diffuse bilateral tuberculous infiltration with no cavity. Paravertebral regional and local novocain-epinephrin anesthesia was used. The ribs from the eleventh to the fourth, inclusive, were resected. Superficial general anesthesia was required for some time. Toward the end of an otherwise well borne operation, that had not been connected with

14. Meyer, Willy: Surg., Gynec. & Obst. **30**:160 (Feb.) 1920.

much loss of blood, sudden unexplained shock occurred, which continued. Subcutaneous stimulation and varied intravenous medication were of no avail. The patient died forty-eight hours after operation.

Epicrisis.—Death was probably due to the paravertebral novocain anesthesia. Several deaths following this kind of anesthesia have been reported from abroad of late. I have abandoned it.

In an excellent article by Goetze [15] of Frankfort-on-Main, recently published from Professor Schmieden's Clinic, the advisability of the resection of the phrenic nerve as a primary operation is emphasized. According to his experience, Goetze believes this operation has to "precede" extrapleural thoracoplasty and "should be added to every case of pulmonary tuberculosis, treated and improved with the help of artificial pneumothorax, before the patient is discharged from the physician's immediate attendance."

2. *Syphilis.*—Lung suppuration in connection with syphilis is not a rare occurrence. Every patient with subacute or chronic lung suppuration needs a Wassermann test; and, of course, a negative result does not necessarily exclude syphilitic infection, should other symptoms point to its probable existence.[16] My personal experience consists of the following cases:

CASE 28.—A man, aged 47, with far advanced lung suppuration, fever, tormenting, continuous cough with expectoration, in whom the roentgenogram simulated that of bronchiectasis, gave a four plus Wassermann reaction. He was seen in consultation, and strong antisyphilitic treatment was advised. Repeated arsphenamin injections were given; later, intramuscular and mixed internal treatment. Today he is completely cured and active in business. He was presented before the meeting of the New York Society for Thoracic Surgery in November, 1921.

LUNG SUPPURATION DUE TO THE PRESENCE OF A BENIGN OR MALIGNANT TUMOR

1. *Benign Tumor.*—This is usually situated within the lumen of a larger bronchus, where it acts, clinically, like a foreign body. Of this, I have had no personal observation.

Chevalier Jackson has seen twelve such cases, not counting one syphiloma, one tuberculoma and seven granulomas, the latter probably being considered secondary to existing suppuration. The twelve cases comprise: one endothelioma, two fibromas, six papillomas, one edematous polyp, one cyst, one chondroma. Of these, the endothelioma had

15. Goetze: Klin. Wchnschr. **1**:1496 (July 22) 1922; ibid. **1**:1544 (July 29) 1922.

16. Landis, H. R. M., and Lewis, P. A.: Latent Syphilitic Infection of the Lung, Am. J. M. Sc. **150**:195-200, 1915. Friedlander, Alfred, and Erickson, R. J.: Syphilis of the Lung, J. A. M. A. **79**:291-294 (July) 1922.

caused suppuration. Inasmuch as the man is alive and well six years after operation, the growth has to be considered clinically benign, though histologically malignant. Of the remaining eleven, one fibroma, one papilloma and the chondroma were associated with suppuration, distal to their insertion; whether the suppuration was secondary or not could not be determined in every instance (personal communication).

Yankauer of New York reported a few such cases at the annual meeting of the New York State Medical Society, held in Albany, April 20, 1922, in which bronchoscopic removal of the growth (fibroma), once from the left, once from the right bronchus and once from the upper trachea, beneficially influenced the dependent lung suppuration.

2. *Malignant Tumor.*—My experience comprises these cases:

CASE 29.—*Cancer of the right upper lobe; bronchiectasis; incision and drainage.* J. B., man, aged 45, was sent from outside on account of bronchiectatic symptoms of two years' duration which had greatly reduced his general condition and caused mental depression. A varying amount of sputum was expectorated, which was of a rather sweetish odor. The roentgenogram revealed a diffuse opacity of the right upper lobe. Bronchoscopy was refused. Rib and intercostal soft tissue resection was performed under local anesthesia. A larger cavity was struck with the aspirating needle, opened and drained. The patient was more comfortable afterward; but there was no perceptible clinical improvement. He died, three weeks after operation. Necropsy revealed an infiltrating suppurating cancer of the lung which had caused the bronchiectasis.

CASE 30.—*Lymphosarcoma and excision of right lung.* A boy, 5½ years. This case was reported under the heading "Lung Excision," as Case 21.

Yankauer [17] emphasizes the fact that spontaneous lung suppuration in middle-aged patients is not infrequently due to the breaking down of a malignant tumor of the lung. He found ten cases of this class among about sixty cases diagnosed as lung abscess (about 16⅔ per cent.). Kully,[18] a former assistant of Yankauer, reports a malignant tumor as the cause of the purulent expectoration in ten out of ninety-two cases of suppuration (10.87 per cent.).

A FEW CASES DIFFICULT TO CLASSIFY

CASE 31.—*Bilateral bronchiectasis.* An undeveloped girl, aged 9, expectorated from one-half to three-quarters of a basinful of very foul pus several times a day, at will. The roentgen rays revealed a shadow over both lower lobes, more on the right side. Operation was performed, June 8, 1911. Repeated thorough expectoration in the knee-elbow posture was accomplished before starting. General anesthesia (anesthol) was employed. Aspiration in various places drew no purulent secretion, but here and there the well-fitting and well-working piston of the record syringe pulled out with ease, the barrel filling with air, without being sucked in again by negative pressure. It was

17. Yankauer, Sidney: Tr. Am. Laryngol. & Otol. Soc., 1920, p. 220.
18. Kully, B. M.: Am. J. Surg. **35**:49 (March) 1921.

recognized that such easy aspiration of air corresponded in value to that of pus and presented sufficient inducement for the surgeon to incise the lung with the expectation of finding the cavity. On dividing the tissues with the cautery in the eighth intercostal space near the spine, the free pleural cavity was opened. The operating table was moved to the positive pressure cabinet and the pressure was turned on. When busy packing the wound for dressing, with the intention of waiting for refilling of the pus cavity for opening at the second stage, sudden collapse occurred, from which the patient could not be revived. Necropsy was not permitted.

Epicrisis.—If air is easily aspirated from a place where pus was drawn before by a reliably functioning syringe, particularly after the patient had thoroughly expectorated, proof is rendered that the cavity has been struck. Of course, it is recognized that in exceptional cases the tip of the needle can rest within the lumen of a bronchus and thus draw in air.

CASE 32.—*Right bronchiectasis.* A woman, aged 26, had been operated on out of town several times before. The fistulas persisted. The roentgen rays revealed a small cavity communicating by a narrow canal with the bronchial tree. There were scant expectoration and scoliosis. She desired operative treatment, since she was a working girl. Operation was performed, Feb. 8, 1913, under local and regional anesthesia. The cavity was laid open by resecting three ribs adjacent to the sinuses. Enlargement of the entrance was accomplished with the actual cautery, which opened a cavity communicating with a number of, as it seemed, partially occluded bronchi, except the one small communication with the bronchial tree seen on the roentgenogram. Tamponade of wound was employed for temporary conservative treatment. If desired, excision was to be performed, later on. There was no reaction. Ten days later, increasingly severe headaches, opisthotonos, strabismus, etc., indicative of suppurative meningitis developed, and the patient died. No necropsy was performed.

CASE 33.—*Bronchiectasis of left upper and lower lobes.* P. C., with bronchiectasis on the left side, the left upper lobe being affected, with purulent material seen by the bronchoscopist also in the left lower branch, but which was considered to have run down, was operated on Dec. 15, 1915. Exploratory thoracotomy was performed for possible excision in the negative chamber under general anesthesia. An oblique incision was made through the axilla forward, with resection of the second to the fourth rib, inclusive. The pleura was incised in the bed of the third intercostal space; the upper lobe of the lung was pinkish and had a number of infiltrated brownish areas. Enlarged glands were seen around the main bronchus. There were firm adhesions with the lower lobe. On trying to enter the interlobar space, lung tissue was inadvertently torn and the escape of some pus was observed. On bringing the diseased lower lobe more clearly into view, it, too, was found visibly involved. Access for total pneumectomy was insufficient. Deeming an immediate additional posterior incision with attack on both lobes unwise, the upper part of the wound was closed by layer sutures. Thorough drainage by means of two gutter tubes at the anterior angle was established, as well as an additional incision in the tenth intercostal space for free drainage. Differential pressure after-treatment was employed. The next morning, the temperature rose to 106 F., respiration 50; likely acute

pneumonia, with or without fulminant sepsis. For safety's sake, change of dressing under differential pressure, gave exit to some additional retained serosanguineous fluid which had thoroughly soaked the dressing. Stimulation had no effect. The patient died at 3 p. m., twenty-two hours after operation. Wound inspection or necropsy was not allowed.

Epicrisis.—1. Lung excision of the lower as well as of the upper lobe requires wide access. The posterior incision (Torek) appears to be best for the purpose.

2. Air-tight drainage is likely preferable to free incision in combination with drainage under differential pressure.

3. In the light of present experience, bolder advance, viz., excision of the entire lung at one sitting, provided the operative attack had been decided on, would likely have given this patient a better chance.

CASE 34.—*Right bronchiectasis.* A man, aged 23, with right bronchiectasis, had been sick for several years. There was continuously a large amount of sputum. A two-stage pneumectomy was planned; first, extrapleural thoracoplasty combined with intrapleural pneumolysis and tamponade, leaving the patient for a while under differential pressure after-treatment, in order to try to produce adhesions around the hilum and reduce the reflex sensitiveness of the pleura; second, from one to two weeks later, excision of the lobe, if possible under local anesthesia. Operation was performed May 7, 1915, in the negative chamber, begun with the door open. Regional and local anesthesia was used, later on general anesthesia was required. Sauerbruch's hook incision accomplished resection of the seventh to the first rib, inclusive, beyond the angle up to the spinal column. When working at the first rib, the pleura tore; air rushed into the pleural cavity and out. The door of the chamber was closed and differential pressure started. The external posterior incision was lengthened forward, penetrating the seventh intercostal space. The lung was found totally adherent, and stripped off. The patient at this time was somewhat cyanotic. The color was not improved after artificial respiration, carried out within the chamber; therefore the operation was discontinued. The lung was covered with a sterile rubber dam and gauze tampons. The posterior wound was sutured, and a gauze tampon was placed in the pleural tear at the first rib. Differential pressure after-treatment was employed, with the patient on the operated side. After twelve hours, the pressure was turned off. The patient's condition was good. He was moved to the observation room, and the upper part of the body was raised. Three hours later, a sudden change occurred in his condition, and death followed a few minutes later. Necropsy and wound inspection were not permitted.

Epicrisis.—1. Perhaps the patient was removed too soon from the differential pressure apparatus. Acute collapse of part of the lung may have caused the sudden change.

2. Tamponade of the pleural tear at the first rib was a technical mistake. The posterior wound should have been closed entirely in the upper part by layer sutures, in spite of the necessity to leave the lower part of the wound open. Differential pressure after-treatment should

have followed just the same. By the time the patient was removed from the pressure cabinet, the pleural tear had likely been sealed air-tight.

C. BRONCHIECTATIC LUNG ABSCESS

Tissue defect, due to local gangrene, usually without progressive symptoms. As stated above, I feel inclined to believe that this class of subacute and chronic lung suppuration is typical for cases of aspiration of septic material of semisolid and liquid character. The aspirated material will, I believe, rarely, if ever, produce "typical bronchiectasis."

1. *Specialistic Treatment.*—To repeat: what cystoscopy and ureteral catheterization, inclusive of the use of the operating cystoscope, accomplishes in urinary surgery, bronchoscopy accomplishes in the early and later treatment of certain suppurative pulmonary diseases.

Bronchoscopy (Peroral Endoscopy).—(a) For the extraction of aspirated foreign bodies, stretching of bronchial strictures due to inflammation, removal of benign tumors, punching out bits of tissue from seemingly malignant growths for microscopic examination, etc.

I have had numerous personal experiences in this class of cases, collected by observation, first in the practice of Dr. Sidney Yankauer of New York City, and later in the bronchiectatic clinic of the Lenox Hill Hospital, conducted by the late Dr. Henry L. Lynah and Dr. Richard Jordan of New York, now by Dr. Jordan and Dr. John D. Kernan, Jr. However, I must refrain from reporting them. I believe that the digest of this part of the bronchoscopist's work, particularly with reference to the stretching of bronchial strictures, the cauterization of granulations, injection of bismuth oil, antiseptic solutions, etc., into the pulmonary cavities for diagnostic as well as therapeutic purposes, belongs to the domain of the specialist.

I shall report here just one personal observation of a foreign body in the trachea that refers to lung suppuration.

CASE 35.—H. H. T., a physician's son, had a continuous cough for years, with purulent sputum commencing after an attack of typhoid fever ten years before. He needed tracheotomy and is still wearing a silver tube. He was brought up on a stretcher from the South in the summer of 1916. After clinical and roentgen-ray examination, bronchoscopy, as in every other case, was performed, as a routine practice (Dr. Yankauer). The tube was introduced through the tracheotomy-fistula. Two irregular foreign bodies were seen and extracted from near the bifurcation. They proved to be sequestrums of thyroid cartilage. The cough was immediately much improved. At the request of the father, the patient was allowed to return to the South. From the report of the family physician, August, 1922, it was learned that the patient was in very good health, no cough; had gained about 30 pounds, and was feeling perfectly well. He still had the tracheal fistula.

It deserves to be emphasized that a timely extraction of a solid foreign body from the bronchial system can quickly improve and cure a patient, threatened with or already suffering from the inevitable consequence of its presence: suppuration.

(*b*) *Prompt, early suction in case of septic lung infection, due to aspiration during nasopharyngeal and other operations under general anesthesia, or to a swim in infected waters with aspiration of such water, also to aspiration during stomach lavage, etc.*

Of the beneficial effect of early, I might call it "prophylactic," suction, I personally can record two cases:

CASE 36.—*Beginning severe lung suppuration subsequent to aspiration of stomach contents during operation.* A man, aged 46, had had an appendectomy plus a cholecystectomy performed by me in October, 1920, under general anesthesia. In the course of the operation, the patient vomited and stopped breathing. Cyanosis developed, but prolonged artificial respiration restored normal breathing. The first two days of the after-treatment were undisturbed; then a rise of temperature occurred with prolonged chills, persistent, most violent coughing spells and typical sputum. The patient was very sick, requiring strong stimulation and careful nursing. As soon as possible, with high fever still present, he was transferred to Lenox Hill Hospital. Prompt bronchoscopy with aspiration (Lynah) was performed and continued at regular intervals for many months (six). Two distinct, small abscess cavities were revealed, closely adjacent, with the fluid level visible in the roentgenogram. The patient and family were opposed to operation. During the last year, endobronchial treatment was used with longer intervals. Today the patient is perfectly well, with no cough, or sputum. Clinical examination was negative. Roentgenologist's report: "Nov. 21, 1922: The lung abscesses in the right upper lobe have apparently completely disappeared."

CASE 37.—L. A., a woman, aged 28, had undergone bilateral tonsillectomy at another hospital. Three days later fever and cough began. One week after operation, the patient expectorated distinctly dark, foul-smelling coagulated blood. On the fourteenth day after the operation, the patient came under my care, with distressing, continuous cough, fetid sputum and high fever. Almost all food was regurgitated in consequence of the paroxysmal phrenic concussions of the stomach. There was right upper lobe affection. She was admitted to Lenox Hill Hospital, April 7, 1921, viz., three weeks after the tonsillectomy. Bronchoscopy by Dr. Henry L. Lynah revealed: acute edema of right bronchus and suppuration from the right upper lobe bronchus. Thorough cleansing of the bronchial tree was accomplished by suction. The cough stopped as by magic; the temperature soon dropped to normal, and the appetite returned. The patient considered herself completely restored to health and left the hospital against advice, after one week. She was lost sight of; but traced by the hospital's social service nurse, whose report, dated April 19, 1922, reads: "Patient in perfect health; no cough; no sputum."

Comment.—To my mind, the therapeutic, one might say "magic," result in this *early stage* of serious commencing suppurative lung infection subsequent to tonsillectomy represents a most important observation.

For a long time, we had been waiting for just such cases. The task was to find out whether early thorough removal of the infectious material by suction could possibly mitigate or cut short advancing suppuration.

Already at this early date in the evolution of this branch of thoracic surgery which promises so much, one likely will not go wrong in saying that results will run parallel with the time of suction, viz., the length of the interval between accident and suction, and the degree of virulence of the aspirated material. It is to be assumed that stomach contents will usually be more infectious to lung tissue than aspirated blood and mucus. This has been proved clinically by untold observations, inasmuch as so many cases of aspiration-pneumonia, subsequent to vomiting in the course of general anesthesia, have proved fatal.

The following four similar cases of this type I owe to the courtesy of Dr. Jordan, and they are here published with his permission.

CASE 38.—C. H., a woman, aged 26, in the fall of 1918 had influenza, followed by a persistent cough for more than a year. In the winter of 1919 she had several attacks of tonsillitis. March 2, 1920, the tonsils were enucleated under ether; one day was spent in the hospital. Two to three days later, while working, severe pain occurred in the left side of the chest, fever, and rapid breathing. March 11, she was seen in consultation by Dr. Jordan. The patient was critically ill, with all the symptoms of an acute suppuration in the left upper lung lobe. The sputum was foul and bloody. The stormy onset of the attack subsided within a week, but the pulse remained weak and rapid and the expectoration profuse and foul. April 7, five weeks after tonsillectomy, she was transferred to the Lenox Hill Hospital. The general condition was still poor, expectoration amounting to 250 c.c. in twenty-four hours.

Physical examination (Dr. Schwerdtfeger) confirmed the diagnosis "lung abscess," which also showed plainly on the fluoroscopic screen in the roentgenogram. First bronchoscopy was performed April 9 (Drs. Lynah and Jordan), a 7 mm. Jackson tube being used. There was a profuse flow of pus through the tube. On entering the left bronchus there appeared an edematous stenosis of the upper lobe orifice, a small opening from which free pus was expelled with each cough. In addition, a membranous plaque was present, which also obstructed drainage from the upper lobe. The slanting end of the tube was gently introduced into the orifice, separating the edematous structure. The membranous plaque was removed by suction. The lower lobe branches were then examined, but no pus was found. Second bronchoscopy was performed two weeks later. The orifice seemed somewhat wider; expectoration was still profuse. With the curved spiral cannula, 8 c.c. of bismuth subcarbonate in olive oil, 5 per cent., was injected. This bismuth could afterward be seen on the roentgenogram within the abscess cavity, although a portion had leaked down into the lower lobe branches. At the third bronchoscopic treatment, April 28, the injection of bismuth-oil was repeated. May 6 (fourth bronchoscopic treatment), decidedly less pus came from the affected bronchus, and the odor was hardly perceptible. The patient continued to improve visibly under weekly bronchoscopic treatments and was discharged, May 29.

She went to the country for about two months and came back fully restored to health. A roentgenogram taken in the fall of 1920 showed the left lung cleared up, except for a remnant of the bismuth in the upper lobe and in the lower lobe branches. According to a recent report by the attending physician, the patient is now in excellent health and is entirely free from cough and expectoration.

CASE 39.—W. C., a man, aged 51, eight years previously had beginning diabetes. Four years previously he had pneumonia on the right side, and was sick for seven weeks. Alcohol had been used freely, until recently. He had a fistula in ano, with several attacks of abscess formation; and he had lost weight within the last three years. The present illness began suddenly, three weeks previously, after an overdose of eating and drinking. The patient awoke with vomiting and gagging, probably caused by aspiration of vomited material at that time. Excessive coughing, with pain on the left side, followed by profuse expectoration, set in and continued.

He was admitted to Lenox Hill Hospital, Oct. 28, 1921. He was still fairly well nourished; very sick; coughed constantly day and night, and had profuse expectoration with a foul odor, a fever of 102 to 103 F. The left lung showed extensive bronchial râles, dulness over the upper portion of the lung; in one area, distinct amphoric breathing. The right lung was normal. The roentgen rays revealed two definite cavities, the upper, corresponding to the sixth interspace was the larger, with a fluid level. The smaller one was in the eighth interspace. Antidiabetic treatment and sedatives were used. November 14, aspiration, with a needle and syringe, was negative. December 3, the second roentgenogram revealed the same findings. The smaller cavity did not contain any fluid, while in the larger one a "fluid level" could be distinctly seen. No special improvement occurred under treatment. Cough and expectoration continued. December 3, bronchoscopy (Drs. Lynah and Jordan) revealed: "Edematous swelling at the orifice of the left upper lobe bronchus. It is possible to pass this stricture with a 7 mm. bronchoscope. Profuse discharge of mucopus follows the stretching. All other lobes free." Bronchoscopy was followed by marked and immediate improvement. Cough and expectoration were much less after a few days, sleep and appetite were better. December 15, second bronchoscopy (Dr. Jordan) revealed: Appearance of orifice of left upper lobe shows a decided change. Edema has almost disappeared, orifice is wide, discharge much diminished. The patient improves steadily and rapidly. He was discharged from the hospital, December 23, and went to the country. All symptoms disappeared within a few weeks. Today, aside from a small amount of sugar in the urine, the patient is perfectly well and working, as usual. The left lung has cleared up; all physical signs have disappeared.

CASE 40.—C. E., a man, aged 24, was admitted to Lenox Hill Hospital, June 18, 1920. Tonsillectomy under ether was performed, June 5, 1920. Cough and fever developed six days afterward; expectoration, three to four days later. Physical examination pointed to a lesion in the right upper lobe (Dr. Schwerdtfeger). Roentgen-ray examination revealed a "triangular dense area surrounding a cavity with a fluid level and air bubble" (Dr. Stewart). Foul expectoration, about 500 c.c. was produced daily. Bronchoscopy, June 29, 1920 (Drs. Lynah and Jordan), revealed copious discharge of foul pus from the right upper lobe only; bronchial orifice, edematous; 10 c.c. of bismuth mixture injected. Second bronchoscopy was performed, July 8, and the bismuth injection repeated, followed by immediate roentgen-ray examination. "Bismuth

was seen outlining numerous cavities" (Dr. Stewart). The quantity of sputum rapidly diminished and had practically disappeared at the third bronchoscopic treatment a week later. The patient made a complete recovery and is perfectly well today. (Reexamination by Drs. Schwerdtfeger and Stewart in June, 1922.)

CASE 41.—A. H., woman, aged 28, was admitted to Lenox Hill Hospital, April 30, 1922. Five weeks before admission, tonsillectomy had been performed under ether. Cough and expectoration occurred a week later. She had been expectorating about a pint of foul pus daily. Roentgen-ray examination, May 2, revealed: "extensive density in the right upper lobe, showing a cavity with air bubbles. Findings are distinctly those of a large, single pulmonary abscess" (Dr. Stewart). First bronchoscopic examination, May 4, 1922, revealed: foul discharge from right upper lobe only, very copious; bronchus distinctly obstructed by edema; 20 per cent. silver nitrate solution applied. The patient was treated bronchoscopically with the application of silver nitrate and injections of a silver preparation, first, every week, then every two to three weeks, altogether seventeen times, until October 26. A distinct improvement was seen after the third and fourth treatments, and the patient has improved steadily since then. There has been no secretion from the infected bronchus since September 28, and the patient feels perfectly well today. The recovery is confirmed by the roentgen-ray findings.

Comment.—If suction alone, or combined with local treatment, by means of bronchoscopy, can produce such remarkable clinical results a few weeks after the aspiration of septic material, it is not difficult to imagine that bronchoscopy with aspiration, as early as possible after the onset of lung symptoms, viz., as soon as the general condition of the patient permits, will reveal still more fulminant improvement. Case 37 proves this. One single thorough aspiration cured the patient. There is no doubt in my mind that not surgery in any form, inclusive of the artificial collapse of the lung, is primarily indicated in these terrible cases, which still occur so frequently, but bronchoscopy, with thorough aspiration, without or with local antiseptic treatment.

(*c*) *Regular suction treatment, with intrabronchial chemical application and irrigation, as well as mechanical treatment (dilatation, etc.) of the affected stem bronchi, in cases of lung suppuration of long standing.*

CASE 42.—V. B., a girl, aged 14, had been well until she underwent a tonsillectomy in the spring of 1914. A few days later, signs of beginning lung suppuration, with the usual concomitant symptoms, set in. The patient was very sick, and was treated expectantly for many months, at her home on the coast. At last the attending physician decided to send her East for relief. While crossing the continent, she was very ill, with high fever. The relatives that accompanied her expected her death on the train. The sudden evacuation of a large amount of pus gave great relief. On her arrival in New York, where she came under my care, she was admitted to Lenox Hill, Hospital. The general condition was much improved. Clinical observation and examination failed to reveal positive signs of abscess, cough with expectora-

tion having abated; but the roentgenologist interpreted the details of the roentgenogram as cavity with the fluid level in the right upper lobe. No operation was advised. The patient was sent to the country where great improvement occurred. In the fall of the same year, she suffered a recurrence. Bronchoscopy revealed all three lobes responsible for the purulent expectoration. Endobronchial treatment was advised and carried out by Dr. Yankauer, weekly, about thirty-two treatments being given from September, 1916, to May, 1917. Gradual convalescence followed. Today the patient is on the stage and enjoying life.

Case 43.—A man, aged 20, had pneumonia involving the right lung in 1918. Four weeks afterward, inflammation set in, and he began to cough pus. The diagnosis was lung abscess in the middle lobe. About six months later, he was referred to the bronchoscopic division of the Lenox Hill Hospital. Pus was seen to ooze from the right middle lobe. Many granulations had formed, causing stricture of the stem bronchus. Stretching of the stricture was followed by cauterization. Regular treatment was carried on there for more than eight months, once weekly, with gradually lengthened intervals. Off and on, recurrent attacks of fever, with hemoptysis and increased sputum, were regularly followed by improvement after bronchoscopy within from five to six days. Today the patient is back at work. There are no further clinical signs of chronic inflammation. The report of the roentgen-ray department, Oct. 26, 1922, was as follows: "The entire right lower lobe shows extensive fibrosis and thickening of the pleura. The right lower main bronchus is considerably dilated. There is some evidence of minute cavitation. The roentgenographic findings would not indicate permanent improvement. I feel confident that this patient is liable to exacerbation if subjected to any unusual exposure." (I owe permission to publish the report of this case to the courtesy of Dr. Torek of the Lenox Hill Hospital, in whose care the patient was on the ward.)

Case 44.—A woman, aged 26, on whom bilateral tonsillectomy had been performed under general anesthesia, four years previously, ten days later developed all the symptoms of lung suppuration. She had four operations at another New York City hospital. At the first and the fourth, pus was found and the cavity drained. She entered the Lenox Hill Hospital in May, 1920, with symptoms of lung suppuration. The first bronchoscopic treatment was given May 25, 1920. Since then, until March, 1922, it has been repeated with thorough aspiration about thirty times. At first, a great deal of secretion seemed to come from all three lobes of the right lung. The stem bronchus was greatly obstructed by granulations, making it difficult to localize the sources of secretion, which was always copious and very putrid. Repeated dilation of the bronchus was performed, together with the injection of bismuth oil, 5 per cent., and the application of silver nitrate, etc. The bronchoscope revealed gradual and considerable improvement. The principal amount of pus formation came from the middle lobe. She was well in the summer of 1920, having little secretion. In the fall, she suffered a relapse and was again improved by the same treatment. Since that time, ambulatory treatment has been given since the patient lives out of town. The immediate effect of the bronchoscopic cleansing was always very marked. The last relapse occurred in the fall of 1921, and she was readmitted to the hospital for the same treatment. At the last examinations in February, 1922, no secretion was seen at any time. The patient was free from all symptoms, and seemed perfectly well. She went to Ireland on a visit for the summer on her own initiative,

from where she wrote under date of July 18: "Since I got home I am feeling just fine. All trace of my illness has left me. I feel just as strong as ever in my life, except if I run very much I get out of breath quickly. I can ride a bicycle, enjoy rowing a boat, dancing and all the pleasures I used to enjoy before I got sick." (Of course, the patient had been strongly advised against risking such stunts.) "I can even work in the hayfields. I was working for two months before I sailed, May 27th, and felt fine, even when I was working in the country I felt myself improving. I really think that having my lung washed out started it healing."

The present condition of these three patients, whose cases are reported under *c*, can certainly be called "much improved." [18] Naturally, not all patients derive the same benefit from this regular intrabronchial treatment, usually done once a week. Some were but slightly improved; others, not improved, left the hospital, refusing operation. I know that a few of the latter are still alive, leading an existence of misery, or have died, later on, at their homes without operation. Experience will have to show whether more frequent treatments, than once a week, for a certain length of time, can do more good in advanced and obstinate cases.

COMMENT

1. The different result, obtained by intrabronchial specialistic treatment, is explained, to my mind, principally by the pathologic variety of pulmonary suppuration. It cannot do much good in typical multilocular bronchiectasis for obvious reasons. It may, perhaps, alleviate the symptoms of these patients, and also, likely, temporarily reduce the fetid odor and the quantity of their sputum, but it cannot possibly bring about a cure.

The treatment promises better results in circumscribed suppuration, the so-called bronchiectatic lung abscess, also, it seems, in cases that had been incised by the surgeon without definite improvement, where, however, increasing connective tissue formation favors Nature's constant endeavors to bring relief.

It stands to reason that in this class of disease the greatest use for intrabronchial specialistic treatment is in the prophylactic field, as already emphasized before, to cut short the threatened spread of the suppuration within the bronchial tree and the adjacent lung tissue, or to alleviate the severity of the infection by the early actual removal of aspirated and decomposing foreign substances from the bronchial tree, a task which cannot be accomplished by any other method of treatment. The cases cited above prove this contention.

It seems significant in this respect, that a single bronchoscopic suction treatment, given three weeks after the tonsillectomy, was capable of curing a patient with beginning lung suppuration due to the aspiration of septic material; that a number of aspirations (two, three and

more), done at intervals of from one to two or three weeks, combined with intrabronchial applications, were required, when the treatment began weeks (twice, three and one-half; twice, five and one-half, six and eight) after aspiration;[19] and that this kind of specialistic treatment, extending over months and years, is required to bring more definite improvement, when the trouble has existed for months and years.

It now will become necessary to corroborate the favorable observations so far obtained by a larger series of successful cases.

2. Regarding the use of bismuth oil, 5 per cent., I do not venture to pass an opinion; it would be premature. In one case, reported below, the repeated injections, done most dexterously with the help of specially constructed ingenious instruments, impressed me as likely having complicated the pathologic picture (Compare Case 49 under "Operation for Bronchiectatic Lung Abscess"). On the other hand, several patients in whom it was used early, were promptly cured.

3. It will also be interesting to find out whether antiseptic lotions used with intrabronchial treatment can dissolve fibrinous coagulations and grumous material, which usually are found within the bronchiectatic abscess cavity.

4. In order to try to find the exact time when patients thus afflicted should be subjected to operation, all patients of this class who were admitted to my service at the Lenox Hill Hospital during an entire year (1920-1921) were first turned over to the bronchoscopic department for treatment. A trying time, to be sure, for the operating surgeon, but considered necessary in order to study definitely the possibilities of endoscopic treatment in this class of cases. If, after a lapse of from six to nine months or more, improvement was unsatisfactory, a joint consultation of endoscopists, roentgenologist, internal consultant and surgeon was held, and an attempt was made to establish the indication for further procedure, whether it appeared right and wise to continue the specialistic treatment, or whether the operating surgeon should take over the care of the patient.

In view of the results obtained and the improvement in the diagnostic classification of patients afflicted with lung suppuration, we now intend to try to segregate these patients soon after their admission to our hospital, advising, from the start, bronchoscopic treatment or operation, or, eventually, both combined.

5. There is no doubt in my mind that bronchoscopy is in the very beginning of its clinical usefulness. Who knows—and I should like

19. With reference to this point, Wessler's statement (J. A. M. A. **73**:1918 [Dec. 27] 1919) must be taken into consideration, that in 33 per cent. of all cases of acute pulmonary suppuration following tonsillectomy the patients recover spontaneously within two months.

to repeat here the words expressed in the early pages of this article—whether the future will not see the trained bronchoscopist also join hands with the internist in fighting typical cases of pneumonia, obstinate in their convalescent stages. It will need courage to do so; but if once started and perhaps if it brings relief in certain difficult cases, the foundation for this team work will have been laid.

2. *Operative Treatment.*—This may be either conservative or radical:

(*a*) *Conservative.*—The operation of choice consists in the establishment of a temporary or permanent lung lip (bronchial) fistula for prolonged drainage and free ventilation of the infected portion of the lung.

(*b*) *Radical.*—If the surgeon or (and) the patient do not want to select the slower, and often more roundabout, procedure of lung fistula establishment, but prefer radical work, lobectomy must be performed.

Before reporting my cases treated with the help of a lung lip fistula, a word should be said concerning the term "lung lip fistula" in contradistinction to bronchial fistula.

We call a bronchial fistula the visible or audible opening of a bronchus, or of one or more of its divisions or subdivisions. The opening is round, sharp-cut, often so small as just to allow the introduction of a probe, but permitting exit and entrance of air, or it is longitudinally or obliquely shaped, etc.

The lung lip fistula, on the other hand, represents the entrance into a visible cavity within the lung and provides for the prolonged or permanent drainage and ventilation of this cavity, which is the result of a bronchiectatic lung abscess. It is artificially arranged for during after-treatment by continuously keeping the pulmonary wound filled with gauze, after incision of the abscess, so that skin cannot join skin, but the latter's border is forced to unite with that of the opening leading into the lung.

Case 45.—In 1911, I operated on a young woman, a physician's wife, who had developed an aspiration pneumonia subsequent to an ovariotomy performed under general anesthesia. After several weeks, she came under my care. Roentgen rays corroborated localization in the right upper lobe, showing multiple small cavity formations, fever, continuous cough with very fetid expectoration. Under regional and local anesthesia, resection of the second and third ribs with the intercostal tissue was performed. Aspiration in the rib bed revealed pus. The abscess was opened about 2 inches below the surface of the lung. It was filled with irregular, partially also round, coagulated masses of fibrin and detritus of the same foul odor as the sputum. The finger when introduced detected a second abscess cavity "around the corner." Prolonged drainage and tamponade was instituted with gradual improvement. The patient returned home under her husband's care. He removed the drainage tube after some time, and the wound healed. Three months later, the symptoms returned. The lung cavity had to be reopened and drained; but this time I kept

it open for six months. The foul odor of the sputum again completely disappeared. Later on, I was told by the husband that the tube slipped out of the wound and could not be reintroduced, and the fistula closed, never to reopen. Today the patient is completely cured, without odor of breath, cough or sputum.

With the experience of the case just reported in mind, in my next case, I did not allow the external wound to close at all, but arranged for the formation of a lung lip fistula.

Case 46.—H. W., aged 26, a school teacher, following an attack of what seemed to be lung inflammation, not due to aspiration, pneumonia or influenza, had developed a pronounced pulmonary suppuration. He had been under the care of several colleagues and was finally declared consumptive, though tubercle

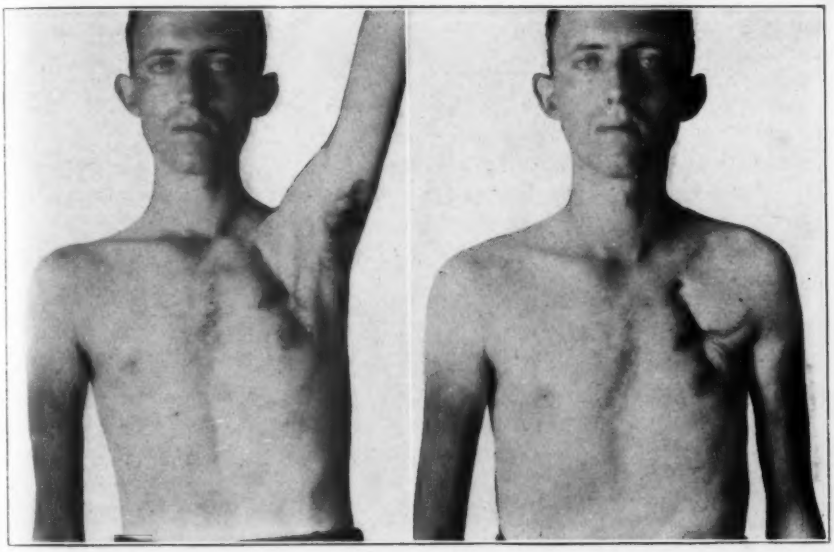

Fig. 4 (Case 46).—Bronchiectatic lung abscess of the left upper lobe due to nonprogressive local gangrene of the lung, clinically cured by permanent, thorough and direct drainage and ventilation of the irregular large cavities, with the help of a lung lip fistula, produced at a two-stage operation under local anesthesia.

bacilli had never been found in his sputum. With his family, he went to the mountains for many months, but did not improve. His sputum became so offensive that he had to be isolated. He occupied a room on the first floor, with the windows always open. His parents asserted that the veranda below was often uninhabitable after the patient had expectorated upstairs. He lost considerable weight and finally developed a small abscess over the third left rib in the mammillary line, which was lanced by the local physician. In this deplorable condition, he came under my care in November, 1916.

After thorough examination and brief observation, the primary indication seemed to be better drainage. This was established under local anesthesia. During the interference, the exploring finger determined the seat of the sup-

puration to be intrapulmonary, not also intrapleural, as might have been possible. As soon as the patient had improved somewhat and his temperature subsided, the operation for the permanent ventilation of the diseased area within the lung was carried out. The operative plan was to resect the overlying rib as far as required and then arrange for a lung lip fistula. This could be nicely done. Under local anesthesia, a goodly portion of the third rib was removed and a large hole leading into the adherent lung exposed. As the patient's left arm was tied down by the chronically inflamed pectoral muscles, which prevented him from raising it beyond the horizontal line, the belly of both muscles was split transversely, down to the ribs and up to the subclavian vessels, so that the two portions of them could retract thoroughly. Then the skin edges were stitched and placed in such a way on either side of the wound leading into the lung that the formation of the lung lip fistula had to result. From this time on the patient made an uninterrupted and most satisfactory recovery, except that once he had a rather sudden profuse hemorrhage from the lung fistula, which, however, could be controlled by tamponade through the opening, and further, that the removal of a gangrenous appendix became necessary. By making him breathe in through the fistula, as described above, and having the nurse, after removal of dressings, direct a current of pure oxygen from the tank into the lung several times during the day, the patient meanwhile keeping his mouth closed and the nostrils compressed, the terrific odor of the sputum quickly disappeared never to return, and the discharge from the wound also ceased completely.

Today he holds a responsible position in a bank in the northern part of the state and is married.

A slight reappearance of the old symptoms in milder form sets in only when, against strict orders, he "jumps the fence" and dances, rides the bicycle or plays tennis. He was warned against going out in a boat, yet he became an ardent fisherman last summer. If his boat ever capsized or if he should fall into the water, it would mean instant death.

According to a letter received in July, 1922, he had, after great mental excitement, a sudden profuse hemorrhage from the lung which stopped spontaneously and did not materially influence his general condition.

To my mind, this case proves that a far-advanced bronchiectatic lung abscess, representing a number of larger and smaller communicating suppurating cavities, can be brought under complete control by thorough direct drainage to the surface and permanent ventilation.

The observation of the gradual convalescence of this patient convinced me that there is "something" in this conservative method of operation, the conservatism in this instance having been forced on the surgeon by the much reduced general condition of the patient. Lobectomy certainly was out of the question. The point of this operative treatment is to see to it that every cavity drains to the surface thoroughly and directly. Today I am still more convinced that the method is a useful one, after having seen and examined this patient, whose case at the time of operation seemed almost hopeless (Fig. 4). It is extremely interesting to look into this "dead crater," six years after the operation, under good illumination with an electric light carried at the tip of a wire

introduced into the depth of the lung. The same central cavity exists, and lateral cavities communicate with it, with a dry surface and blood vessels pulsating and shining through the many dividing walls diaphanously. And the patient has neither cough nor expectoration, and the expired air is odorless. He is cheerful, energetic and able to work.

The cavity, of course, cannot contract, as the lung is completely adherent to the parietal pleura, a fact which explains, to my mind, why, now and then, under particularly increased blood pressure (undue exercise, mental excitement, etc.) a hemorrhage sets in.

To cure the patient completely today would, of course, require the excision of the diseased portion of the lung, here the left upper lobe. However, I cannot find the indication to propose it, as it might easily prove disastrous; besides, the patient will not consent to it. But do not some patients have to carry a renal fistula throughout their lives, if, for example, the condition of the opposite kidney forbids nephrectomy?

A somewhat milder course of operative treatment, which eventually might also bring the cavity to a close, would be extrapleural thoracoplasty in the upper portion of the left side of the thorax, with circumcision of the fistula and closure of the hole by suture, the latter to be done at a second stage, some time after the first.

This case again proved to me a phenomenon I had seen before and commented on in presenting such patients before various medical societies, namely, that these suppurating lung cavities evidently are inhabited by "partially" anaërobic bacteria (probably saprophytes), that were responsible for the terrific, indescribably foul odor, and live and multiply because of the insufficient physiologic ventilation through the trachea and bronchial system, but perish as soon as "volumes" of air and oxygen have direct and unobstructed access.

This was the first patient with a chronic nonspecific lung suppuration, who was intentionally operated on and treated with the formation of a lung lip fistula. Since then, three more patients, equally afflicted, were similarly treated, and two of them also cured of the suppurative lung inflammation.

CASE 47.—A man, aged 40, a chauffeur, came under my care not long after. Immediately after an operation for circumcision under general anesthesia (ether), in June, 1916, a bronchiectatic abscess developed in the right upper lobe. A rise of temperature, reaching 104 F., set in soon after the operation and lasted for four weeks. One week after the operation, he began to cough, and then, for the first time he felt a sharp pain in the right axilla, with symptoms of dry pleurisy. He then went to the Adirondacks where he did some light work. In the fall of 1917, increased temperature was noticed and a foul odor to the sputum. Almost constant cough and expectoration developed, the latter of a very offensive rather sweetish odor, varying in amount from 16 to 24 ounces in twenty-four hours. It did not contain any elastic fibers or tubercle bacilli. Physical examination revealed fine râles over the right third rib, also

some indefinite fine râles over the lower chest on the right side. The left lung was normal. The roentgen rays revealed marked cloudiness of a patchy character throughout the upper three fourths of the lung, more marked in the middle third; some stringlike shadows visible throughout this cloudiness, and a peaked diaphragm. A nonspecific suppurating focus in the upper right lobe was diagnosed, and the patient sent to me for operation. In January, 1918, under regional and local anesthesia an incision was made slightly convex downward, in the second intercostal space. The major and minor pectoral muscles were divided, incising a portion of each perpendicularly to its fibers later on in order

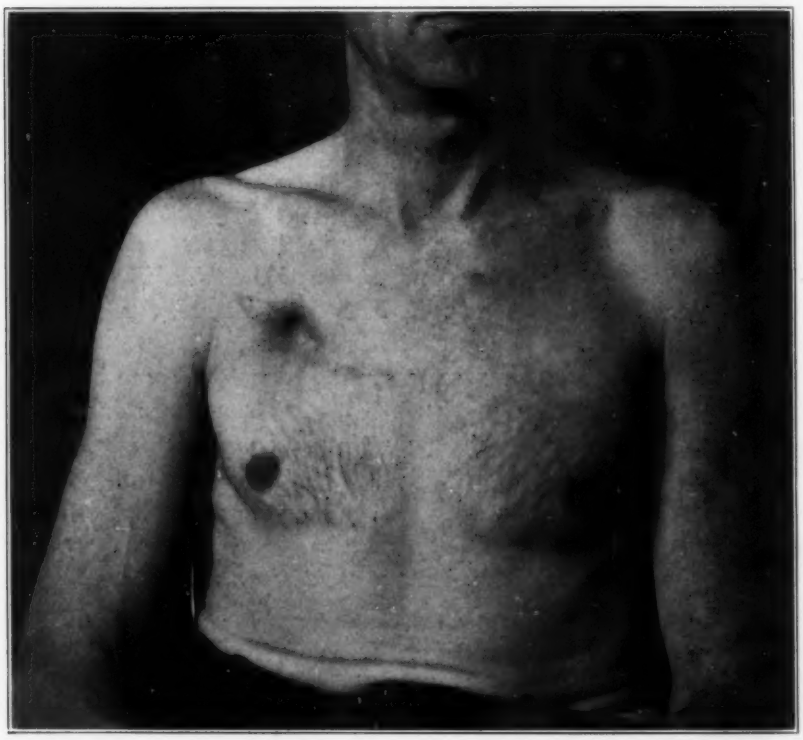

Fig. 5 (Case 47).—Bronchiectatic lung abscess of the right upper lobe, due to aspiration during general anesthesia for circumcision. Pneumotomy was performed under local anesthesia, arrangement being made for the establishment of a lung lip fistula, which still persists after four years. The lung trouble is cured, and the patient is opposed to having the fistula closed.

to gain sufficient space. Resection of 4 inches of the second rib was performed. Careful division of the intercostal muscles proved that the lung was not moving, the pleural leaves being evidently adherent.

Aspiration was performed with a long needle of large caliber in the bed of the resected second rib, the needle being pushed on in a straight direction backward, with a clear sensation of penetrating infiltrated tissue, and then suddenly entering a cavity. Aspiration drew some arterial blood, with distinct pus flakes in greater quantity. The lung was incised with the cautery, carefully

following the needle as a guide. On reaching the tip of the needle the cavity was struck and widely opened. It contained coagulated masses of fibrin of various sizes and shapes and of the same foul odor as the sputum had shown for many months. The finger when introduced palpated an irregular cavity, with a perpendicularly forward rising and resistent arch, evidently the posterior wall of a distended larger bronchus. Upward the flexed tip of the finger entered a smaller pocket "around the corner." The cavity lay fully 2½ inches below the surface of the lung. Drainage was established with a split rubber tube. Iodoform and sterile gauze tampons were inserted and loose dressing applied. The patient was in splendid condition after the operation, and had noticed hardly any pain. One week later, the first change of dressing was made. The lung wound now represented a large cylindric hole in the depth of

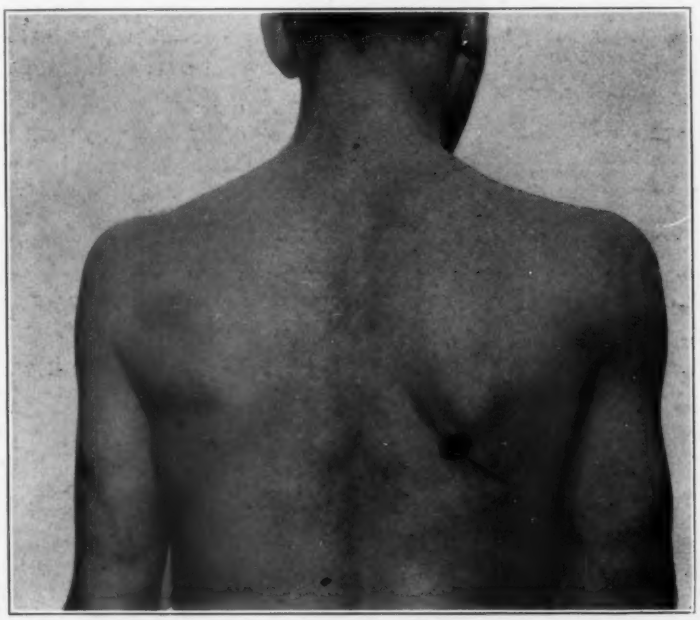

Fig 6 (Case 48).—Nontuberculous bronchiectatic lung abscess of the right lower lobe, due evidently to septic embolism of low virulence, with subsequent localized nonprogressive gangrene. Incision and clearing the cavity from the fibrinous coagulations were accomplished under local anesthesia. Persistent drainage was established for the sake of forcing epithelization of the external opening; successful.

which one large and several smaller opened bronchi were visible. Retamponade was performed. In the course of further after-treatment, care was taken to establish a lung lip fistula. After its definite formation, lasting several months, the rubber drain was removed. In July, 1919, the patient reported that he was in fine trim. He had a slight morning cough, felt in perfect health and was able to work. Today, four years after operation, the artificial pulmonary fistula is still present. Its skin entrance is collapsed. When its lumen is separated, and with the patient's lips closed and nostrils compressed, the

required quantity of air for ordinary respiration can easily be drawn through the fistula. There is no cough, no expectoration and no fetor from the mouth. The patient is at work as a chauffeur and is in splendid physical condition (Fig. 5). He is opposed to having the fistula closed at present.

The foregoing experiences, though few in number, appeared significant to me at that time and convinced me, as already stated, that the establishment of a pulmonary lip fistula is a useful operative procedure

Fig. 7 (Case 48).—Wound closed spontaneously and permanently; patient entirely well; coexisting bilateral tuberculous epididymitis, suppurating on one side, was much improved by persistent hyperemic treatment. Today scrotal fistula is closed.

along conservative lines in advanced cases of bronchiectatic lung suppuration, when excision of the lung is either refused by the patient or his family, or it is contraindicated.

I decided to try it further, and an opportunity soon presented itself.

CASE 48.—A man, aged 25, came under my care with a bronchiectatic lung suppuration in the right lower lobe. This time, aspiration had not taken place. The abscess had developed with an attack of fever and had made the patient miserable. Repeated sputum analyses proved the absence of tubercle bacilli. A long stay in the mountains had failed to bring relief. The foul odor of the sputum necessiated his admission to the isolation house at our hospital. The roentgen rays revealed a fluid level in the right lower lobe. The roentgenologist of our hospital, Dr. William H. Stewart, had localized the abscess and advised aspiration, 8 cm. to the right of the spinous process of the dorsal vertebra, which was found, on measuring, to be 20 cm. below the spinous process of the seventh neck vertebra. The aspirating needle found pus at this place. Two days later, under regional and local anesthesia, and with the patient sitting on the operating table, the cavity was found after rib resection, and exposed with the actual cautery. It contained a collection of large and small masses of coagulated fibrin of the same fetid odor as his sputum. Recovery was uninterrupted. I taught his wife how to secure a permanent drainage tube in the wound leading down into the cavity, which was almost 2 inches below the surface of the lung. After the lung lip fistula had formed, which took about six months, and the spontaneous closure of the canal was believed to be impossible, the tube was left out (Fig. 6). Cough and sputum had disappeared long before, and the patient's breath was sweet. He was told to present himself at regular intervals. After some time, he failed to appear and was lost sight of. Through the efforts of our social service nurse at the hospital, he was recently traced, and, on presentation, the fistula was found to be completely healed (Fig. 7). The wound had closed against expectation. There is no cough and no sputum.

An interesting concomitant feature in this case was the presence of a bilateral, chronic tuberculous epididymitis, which I treated with Bier's hyperemia. Still, the lung trouble was surely nontuberculous, as proved by the location of the abscess (lower lobe), the freedom from disease of both apexes, the persistent absence of tubercle bacilli and the negative result of the complement fixation test, as well as postoperative developments. It had been my intention to favor the closure of the lung fistula (which here, too, provided for sufficient aeration when the patient was told to close his mouth and compress his nostrils), by extrapleural thoracoplasty, in order to effect collapse of the affected portion of the lung, aided by external elastic compression, and then freshen the walls of the canal with the actual cautery. The patient's failure to appear frustrated this plan, and Nature did the work alone.

For a complete, immediate cure, lobectomy would have been the operation indicated. To this, the patient was opposed, in view of his having been recently married. His wife, too, refused to consent to a more risky operation.

The case proves that such prolonged ventilation can produce a spontaneous cure after months, without the patient's having to wear a tube or tampon continuously in the wound for drainage, the ventilation being secured by forcing the scar tissue to line a large opening or dip into

a narrower canal and prevent the formation of a bottle-wound as well as the entrance of the bottle's neck closing prematurely. A similar observation was made in Case 45.

A more rapid collection of additional cases in which operation was thus performed became impossible. Since a bronchiectatic clinic had

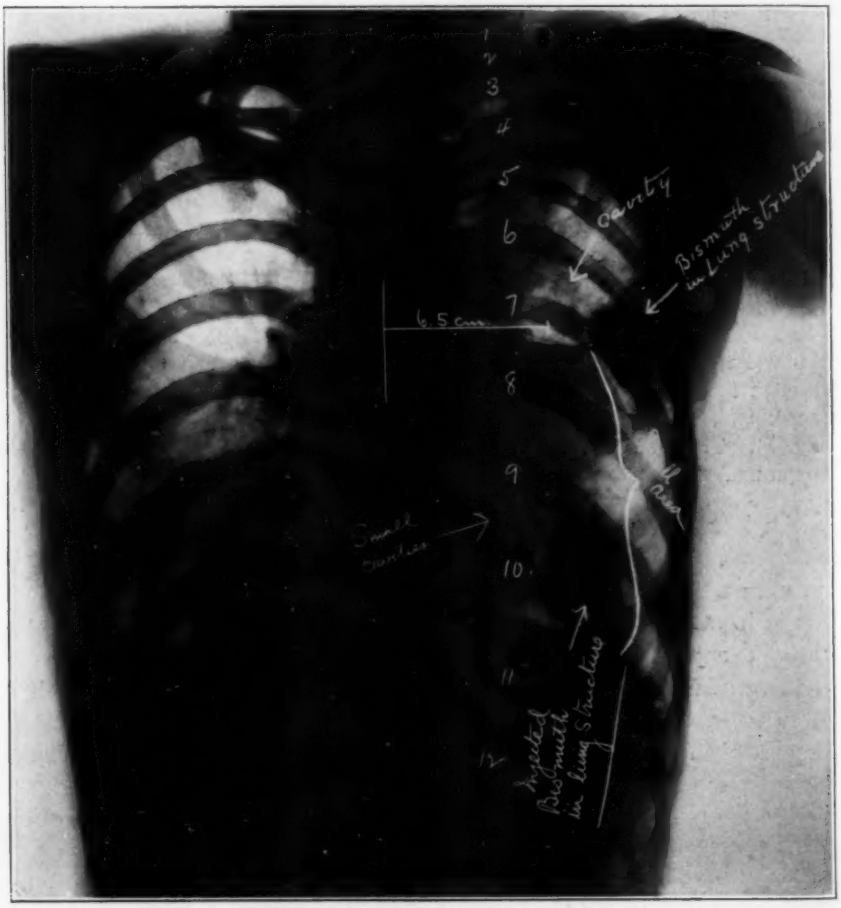

Fig. 8 (Case 49).—Roentgenogram taken in the course of the preoperative bronchoscopic treatment of the bronchiectatic lung abscess, which proved to be of hour-glass shape later on. The distinct shadows within the lung parenchyma are due to the injection, for diagnostic and therapeutic purposes, of 5 per cent. bismuth oil into the stem bronchus of the lobe, harboring the abscess. The fluid level in the lower portion of the abscess is clearly visible.

been created at our hospital, I considered it my duty, as mentioned above, to turn over suppurating lung cases that had come under my care to the clinic first, in order to find out the possibilities of this

fascinating specialistic treatment and to observe how many of these patients would definitely cross the border line into surgery, and at what period.

Of those left to Drs. Lynah and Jordan, only one has come back under my care for operation so far:

CASE 49.—A woman, aged 26, who had always been healthy, developed serious lung suppuration subsequent to tonsillectomy, which was performed at another hospital in October, 1920. She had persistent high fever when the

Fig. 9 (Case 49).—Bronchiectatic lung abscess treated by pneumotomy, with prolonged drainage and ventilation; preoperative bronchoscopy and the injection of bismuth oil. Illustration shows the lung lip fistula in the process of its establishment.

endoscopic treatment was started. Trials with the direct injection of 5 per cent. bismuth oil through a long tube with a movable tip, advised by Dr. Lynah, and introduced through the bronchoscope, were made (Fig. 8). A bougie cure of the contracted bronchus was resorted to, with direct cauterization of the easily bleeding granulations at this place. Such treatment followed primary, thorough evacuation of the purulent, foul sputum by suction, but the patient did not improve. She developed a larger cavity in the right lower

lobe, proved by clinical and roentgen-ray examination. Unfortunately, bronchoscopic and clinical findings did not completely tally, for endoscopic inspection also proved the middle, perhaps also the upper lobe, to be affected. Dec. 14, 1921, under regional and local anesthesia, the cavity in the right lower lobe was exposed and drained with the help of the lower portion of the anterior half of a Schede incision, permitting partial resection of the fourth to the seventh ribs, inclusive. The intercostal soft tissues were also removed. In the axillary and postaxillary lines, the normally colored lung was seen in the various intercostal spaces to move with respiration. There were no adhesions between the lung and pleura in this region; but nearer the spine, the lung appeared darker, almost black, and did not move. Evidently it was adherent.

Fig. 10 (Case 49).—Both portions of the hour-glass shaped abscess laid wide open after additional rib resection at the time of the second operation; patient still under treatment.

Aspiration with a large needle detected pus, and exposure with the actual cautery led to a long, stretched and irregular cavity, which, as in the foregoing cases, contained very foul smelling fibrinous coagulations of various shapes and sizes. These were carefully removed. The immediate addition of the posterior Schede incision and resection of the seventh to fourth rib farther backward, in order to lay the suppurating field in the lung more widely open, seemed most desirable. But the patient's condition at the completion of the incision of the abscess forbade it at that time. Drainage of the wound with strips of iodoform gauze and split drainage tubes was established. Cough,

sputum and odor disappeared at once; but the fever persisted, proving the existence of other trouble within the lung. The lung lip fistula formation was sought at once (Fig. 9), and thorough persistent respiration through this back door insisted on, while tonic and other medication, later a blood transfusion, kept the reduced patient alive. After six weeks, the fever subsided, and the sputum, which had sometimes still amounted to as much as 350 c.c. in twenty-four hours, always without odor, commenced to diminish in quantity. April 9, the patient left the hospital, and went to her home. The wound was dressed three times every week and the patient was urged to inhale through the artificial opening as much and as often as possible. She improved and gained in weight. Recently, some increase in temperature and in the quantity of sputum developed, so that the additional posterior incision, with freer opening of the affected area, became necessary. It was done, again under local anesthesia, by my associate at the Lenox Hill Hospital, Dr. O. C. Pickhardt, July 20. After resection of the rib stumps, the seventh to the fourth, inclusive, backward beyond their angle, and after excision of the intercostal soft parts, the lung was split posteriorly upward with the cautery, a grooved director being held within the whole length of the fistulous tract, with comparatively little hemorrhage. When near the upper end of the tract, the director, held by the first assistant, suddenly slipped further upward for quite a distance. On resecting two additional ribs above and splitting the lung further, the exploring finger suddenly entered a cavity in the upper lobe (or in the uppermost portion of the lower lobe) which contained the same masses of coagulated fibrin of very foul odor such as had been found in the first cavity, farther down in the lung, several months before. With drainage by means of split tubes and aseptic tampons, the wound was left wide open (Fig. 9). The patient is now on the road to further recovery.

It is hoped that the direct permanent ventilation of the lung lobes—the only operation feasible under the circumstances—will also restore this patient to a fair degree of her former health. It would be a splendid example of our ability, to give help in such complicated cases of lung suppuration by means of a more conservative operation, and restore them gradually as useful members of the community.

COMMENT

The five patients, whose histories have just been reported, have been presented before various medical societies in the course of the last few years and their cases discussed. Should I venture to express a conclusion on the basis of the experience gained, I would say that the method promises great improvement, if not an ultimate cure, in certain cases of this type, in stages, and that with a comparatively small rate of mortality. Of course, it must not be forgotten that so long as the canal remains open these patients cannot be considered cured, even if the former lung suppuration has completely subsided. They cannot take a bath, even in the tub, or go in swimming, nor must they ever fall into the water, for instance, while out fishing. Instantaneous death by flooding the lung would be the consequence.

It is true, it might be possible to close the opening with a cork, and, in addition, construct a snugly-fitting and safe suction rubber cap with inflatable neck, as we see it attached to the masks for general anesthesia, to make the fistula air-tight. Still, with the body immersed in water, the life of the patients would depend on the proper working of such a device. The slightest leak, and they would drown instantly.

When the patients have recovered and have been discharged from the hospital, they appear perfectly well. In the case of a severe cold or of undue, and, of course, forbidden exercise (bicycle riding, dancing, playing tennis, etc.) temporary exacerbation may set in later on, with accompanying cough and reappearance of sputum, which is often streaked with blood; also mild fever. However, as stated above, these phenomena are only temporary. The patients soon regain their former greatly improved state and are able to work. Their weight increases; bachelors even marry, and they are so well satisfied with the improvement attained that they refuse the second part of the work planned, the closure of the canal or opening. So far, I have had no chance to attempt closure of the lung fistula, which I think would best be done by means of a circular excision of the skin lip fistula, cauterization of the canal that leads into the lung and collapse of the chest wall by extrapleural thoracoplasty.

In two of the patients just reported this lip fistula has closed spontaneously; both are completely cured.

In conclusion of this report on personal experience in the operative treatment of lung suppuration within the last twelve years, I would emphasize that, as a matter of necessity, the presentation of this subject is necessarily of a somewhat tentative character. The observations made merely demonstrate our efforts to find the operation best suited to the case in hand. I realize fully that we stand but at the very threshold of this important field of thoracic surgery and that the personal views cited above may have to be modified, perhaps considerably, in the course of time.

RÉSUMÉ

1. Bronchoscopy is of great importance in the treatment of acute, subacute and chronic, nonspecific and nonmalignant lung suppuration.

It cannot possibly bring lasting benefit in the typical bronchiectatic case. However, it seems to deserve a permanent place in the specialistic treatment of the bronchiectatic lung abscess. It will likely have its triumphs, if resorted to primarily and promptly, in order to stop completely or reduce the advance of a beginning lung suppuration due to aspiration. The earlier the evacuation of the aspirated infected material from the bronchial tree by means of suction can be carried out, the greater, it seems, will be the chance for lasting improvement and for a definite cure.

2. Of conservative operative procedures, two appear to deserve recommendation: (*a*) ligation of a branch of the pulmonary artery, best combined with extrapleural thoracoplasty at a second stage, in typical bronchiectasis, if lobectomy is contraindicated or refused; (*b*) the establishment of a temporary or permanent lung lip fistula for prolonged drainage and thorough ventilation in the case of a bronchiectatic lung abscess.

3. The typical unilocular lung abscess can heal spontaneously. Otherwise, it is curable by incision and drainage. The difficulty for the operator lies in properly localizing the focus within the chest before operation. Roentgenography promises to assist the surgeon greatly in this respect.

If a preoperative, definite localization of the focus was not possible, then, during the operation, a wider rib resection, with excision of the intercostal soft tissues and inspection of the pulmonal pleura with reference to color and mobility from without, or, as a last resort, incision of the pleura and intrapleural palpation, will, in the majority of cases, reveal where the lung is adherent. Beneath such adhesion, the abscess is usually found. It will be a very rare occurrence in typical lung abscess to find the lung absolutely free from adhesions to the chest wall.

Preoperative aspiration is not advisable. Aspiration with needle and syringe is best done in the course of the operation, when the adherent portion of the lung has been definitely made out.

Incision of the abscess should, if possible, be carried out at one and the same sitting, provided the adherent part of the lung is found, or at a second stage, according to anatomic findings and complications arising in the course of the operative work, after the infiltrated portion of the lung has been stitched in place.

In view of the fact that the lung usually is adherent to the chest wall corresponding to that portion of the lobe which harbors the abscess, it is hoped that a method will be found, roentgenographically, which will show the looked-for lung adhesion in the roentgenogram, and thus obviate the necessity of pleural exploration by the operator's hand.

4. Lobectomy (resection of the lung), as the most radical operation, promises an absolute cure. It should be selected on strict indication and with due respect to the patient's general condition. Its present rate of mortality will no doubt be further reduced in the near future.

CONCLUSIONS

The foregoing cases of subacute and chronic lung suppuration are all that have come to me for operation within the last twelve years. It is a rather small and modest showing, small as far as the number of

cases is concerned, and modest as regards the quality of the results obtained. However, as all have been observed and treated by one and the same man, their histories, operations, after-treatment and results may contribute, it is hoped, to some slight extent, to the evolution of this chapter of thoracic surgery.

On analyzing the quantity and quality of the material presented, it must be remembered that twelve years ago thoracic surgery was a rather new field, that the number of colleagues who recognized this addition to the chapter of border-line cases was small in the beginning; that some of those who at first had enthusiastically referred their chronically ailing patients with thoracic diseases to the surgeon were perhaps sometimes disappointed in not seeing, at once and more regularly, positive results, and then hesitated in advising operation to patients similarly afflicted; and, further, that many of the most enlightened soon had to enter military service.

Besides, thoracic cases are scarce as compared with abdominal cases, and at the Lenox Hill Hospital of New York City the division of service according to the type of disease (thoracic, abdominal, urinary, extremities, etc.) could not be introduced so far. Every surgeon there is actively engaged in thoracic work, an arrangement which also has its great advantages, since it enables many minds to work on the solution of difficult problems.

A hand was also lent to determining the value of intrabronchial treatment, which naturally contributed to a reduction of the number of cases reaching the surgeon.

Furthermore, regarding admission of patients with advanced cases of consumption for operation, the laws of the New York State Board of Charities forbid the admission of patients with active tubercle bacilli in their sputum to our wards. It will be advisable for the hospital boards, at least in the state of New York, to set aside some small ward, or, if not available, a few small rooms for the operative treatment of these patients.

Although it will perhaps be seen, in the near future at least, that the surgical treatment of thoracic diseases, including cases of patients afflicted with advanced pulmonary tuberculosis, will become specialized, nevertheless, it seems to me, all general hospitals should be prepared to help those in this deplorable state. In every large hospital, I am sure, at least one surgeon will be found who is ready to operate on patients suffering from troubles above the diaphragm. I believe that, in the end, thoracic surgery will develop in such a way that surgeons universally will take it up, and, like abdominal surgery, it will be in the hands of all.

That the quality of end-results of the cases reported above is not better also has, in part at least, its explanation. Twelve years ago, we

were not capable of making a differential diagnosis of the various types of subacute and chronic lung suppuration—each of which has, it seems to me, its special type of surgical interference—as we are able to do, more or less at least, today, and to select the special type of surgical interference called for. Often we were groping in the dark in order to determine what it was best to do in the given case and how to do it. The cases of the patients sent were usually far advanced. Having been recommended to the "surgeon," almost everyone was submitted to some kind of operation. Operations were consequently performed which we would refuse today, and some patients were submitted to an interference which we would consider not indicated with our present knowledge. But by way of disappointments and subsequent self-scrutiny, by the cooperative work with the bronchoscopist and roentgenologist, and also by observing and analyzing satisfactory and pleasing results, more light was gradually thrown on a field which at first appeared to us rather bewildering and dark. Incidentally a few principles for personal guidance in thoracic work in general were evolved which may perhaps also help others in this arduous, yet so immensely fascinating field: (1) to be prepared for the application of differential pressure in every thoracic operation, in order to meet the possible deleterious effects of an operative collapse of the lung; (2) to push local and regional anesthesia to the limit, for the sake of avoiding, as far as possible, aspiration of pus into, and subsequent inflammation of, hitherto nonaffected portions of the lungs; (3) to try to restore physiologic conditions at the completion of the operation, yet take care of the usually occurring postoperative effusion of fluid into the pleural cavity, which calls for complete closure of the chest wound with air-tight drainage.

PROCEEDINGS

Saturday, April 29—Morning

The meeting was called to order at 9:30 by Dr. Willy Meyer, New York, the president, Dr. Samuel Robinson, Santa Barbara, Calif., being unable to be present.

Dr. Nathan W. Green, New York, in the absence of Dr. Samuel Robinson, read the president's address on "The Present and Future in Thoracic Surgery."

Dr. Rudolph Matas, New Orleans, read a paper on "Anterior Median Thoracotomy by Complete Longitudinal Division of the Sternum for Thoracic Decompression."

Dr. Hermann Fischer, New York, read a paper on "Surgical Treatment of the Esophagus."

Dr. Howard Lilienthal, New York, read a paper on "Posterior Mediastinotomy."

Dr. Wyman Whittemore, Boston, read a paper on "Teratoma of the Right Chest Cavity."

Dr. Sidney Yankauer, New York, presented "A Radium Needle for the Esophagoscope."

Discussion was opened by Dr. Edward W. Archibald, Montreal, Can., followed by Drs. Leon T. LeWald, New York; Franz J. Torek, New York; Evarts A. Graham, St. Louis; Karl Schlaepfer, Baltimore; Robert T. Miller, Baltimore; John L. Yates, Milwaukee; Carl A. Hedblom, Rochester, Minn.; Nathan W. Green, New York; Willy Meyer, New York; Rudolph Matas, New Orleans; Hermann Fischer, New York, and Howard Lilienthal New York.

Saturday, April 29—Afternoon

Drs. Leon T. LeWald and Nathan W. Green, New York, read a paper on "The Differential Diagnosis Between Tuberculosis and Lung Abscess."

Dr. A. L. Lockwood, Toronto, Ont., read a paper on "Lung Abscess."

Dr. Evarts A. Graham, St. Louis, read a paper on "The Surgical Treatment of Bronchiectasis."

Dr. G. J. Heuer, Cincinnati, and P. M. MacCready, Baltimore, read a paper on "Lung Abscess."

Dr. Willis S. Lemon, Rochester, Minn., read a paper on "The Interrelationship and End-Results of Chronic Suppurative Diseases of the Lungs."

Dr. Karl Schlaepfer, Baltimore, read a paper on "Fibrosis of the Lung Following Ligation of the Pulmonary Artery, Combined with Phrenicotomy and with Partial Occlusion of the Pulmonary Veins."

Dr. Willy Meyer, New York, read a paper on "Observations on Lung Suppuration and Its Treatment: A Brief Review of Personal Experiences and Clinical Impressions Obtained Within the Last Twelve Years."

No discussion.

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Dr. Franz Torek.....1021 Madison Avenue, New York.
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